your source for keeping your home comfortable, safe, durable, and efficient
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ELECTRONICS 15%
LIGHTING 10%
APPLIANCES 13%
WATER HEATING 15%
HEATING AIR CONDITIONING 55%

Home Energy Use
A typical Minnesota household uses about 180 million British Thermal Units (mmBTU) of energy every year to heat, cool, light, and operate appliances and electronics.
Because one-fifth of the energy consumed in our state is used in residences, each of us has the opportunity to affect overall energy use and its effects on our environment.
This guide is designed to help you improve the operation, safety, and comfort of your home and to provide guidance for making smart energy efficiency choices.
How, when, and in what form we use energy can have a dramatic effect on our lives, our bank accounts, and our environment. Using energy wisely makes sense and is a goal that we all share.

The average Minnesota family spends a significant amount of money on energy, but we can dramatically reduce these costs—up to 30%, according to the U.S. Department of Energy—by making some simple energy-saving improvements to our homes. In addition to saving money on utility bills, we can protect our homes from moisture damage year-round, reduce problems caused by ice dams on the roof during the winter, significantly cut summer cooling costs, extend the life of houses, and sometimes increase resale values. Furthermore, reductions in energy use also reduce environmental effects, including lowering contributions of carbon dioxide and other greenhouse gases.

**Building Science**

The interactions of the various parts of buildings have become better understood in the past few decades. The efforts of manufacturers, designers, architects, engineers, researchers, and builders to consider how homes operate safely, and builders to create durable homes that operate safely, and manufacturers, designers, and builders to consider these parts have become better understood in the past. The interactions of the various parts of buildings have become better understood in the past several decades.

## Homes are no longer simple

When many of our homes were built, there was little concern about energy conservation and efficiency, therefore little attention was given to things like insulation and air leakage. Energy was cheap and construction materials and techniques were sufficient for the time. Over the past several decades our homes (and the things within them) have become increasingly complex. Rising energy costs, along with environmental and other concerns, have increased awareness and driven research into the operations of buildings. The effects of the interactions of structural systems, weatherization components, mechanical equipment, and electrical devices in today’s homes are the subject of an entire field of study: building science.

**Saving energy benefits everyone**

Depending on your home, you may see substantial reductions in your energy use through conservation and efficiency improvements. Even if the annual savings for your home are modest, however, they go on, year after year. Many energy improvements will save enough money to pay for the initial investment in just a few years—some even sooner!

Also, the cumulative effects of thousands of Minnesota families reducing their energy use will pay big benefits to all of us. We use a great deal of energy in our state, and the majority of it is derived from fossil fuels—all of which must be imported into our state. Anything that we can do to reduce the emissions from burning coal and petroleum products will help to slow the rate of climate change and have a positive impact on air and water quality. Additionally, investments in energy-related home improvements help to grow jobs in Minnesota—from contractors and installers to manufacturers and retailers.

### What should be done first?

Many people assume that there is little they can do to significantly reduce their energy use and increase the efficiency of their homes. In reality, there are many things that typical residents can do themselves and many other things they can hire others to do. Before you start on any large project, you should know what options you have and what the benefits may be. Today’s homes and their systems are much different than what was common 20, 30, or 50 years ago. The interactions between the various components of a house are more complicated, and the effects of systems not performing properly or being out of balance can be costly and sometimes dangerous. The Division of Energy Resources in the Minnesota Department of Commerce strongly recommends having a home energy assessment (sometimes called a home energy audit) before embarking on your energy improvement projects or remodeling. This assessment of how your house is functioning can help you decide what needs fixing, what needs upgrading, and what needs replacement. Many people have a follow-up inspection after work has been done to verify the estimated energy savings.

**Energy assessment: how your house works**

A home energy assessor will evaluate the operation of your home by inspecting and measuring the performance of the building. At minimum several things should be included:

- A review of energy bills to identify basic usage and identify opportunities for savings.
- A blower door test to determine air leakage rates.
- Infrared camera scans of walls, attic, and foundation to assess insulation levels and locate possible air leak sources.
- Efficiency and safety testing for combustion appliances (like furnaces, boilers, gas fireplaces, and water heaters) to ensure they are operating properly and not contributing to indoor air concerns.
- A visual inspection for attic, wall, crawl-space, foundation, basement, window, door, and roof problems.

Although many inspectors include some of these tests as part of a general home inspection, it is important to have all of the above tests completed by a trained and qualified energy assessor in order to determine the best approach to improving the energy performance of a home.

### When should you get an energy assessment?

Most homes—even recently built ones—can benefit from an analysis of the operation and interactions of the various systems and equipment. There are times when having a professional diagnosis can solve complicated problems while saving time, energy, and money. Consider an energy assessment before:

- Replacing equipment (such as a furnace, boiler, water heater, vent, or air conditioner). Finding and addressing air leakage, insulation, and other issues can help to correctly size new appliances and ensure they will work as efficiently as possible.
- Replacing windows, doors, or siding. Properly installed, these improvements can make your house much tighter, which can change the fresh air requirements for some combustion appliances or for the occupants.
- Investing in major remodeling or additions. Knowing the current operation of the home can help determine choices about designs, methods, or equipment options. In addition, pre- and post-construction testing can be used to verify energy performance improvements.

**Problem-solving systemic or complex concerns,** such as excess moisture (including condensation, mold, mildew, or leakage), uneven heating or cooling, drafts, ice dams, or high energy bills.

**Buying or selling a home.** Many people already include a requirement for a home inspection as part of a purchase agreement. Although this may identify structural issues, mechanical system problems, code violations, and other health and safety issues, the typical home inspection may not provide a complete look at the energy usage for a home. An energy assessment will highlight energy-saving improvements that can reduce utility costs and improve the health and comfort of future occupants.

**How much does an energy assessment cost?**

Home energy assessments that meet the suggested minimum requirements cost from $100 to several hundred dollars, depending on the level of detail and the types of tests provided.
SAVING ENERGY MAKES GOOD SENSE

How hard is it to make energy improvements?

If you have some basic tools and are comfortable with making repairs and improvements to your house, you can handle a lot of the projects suggested in this booklet and make the most of your energy-improvement budget. Be sure to check with your local municipality for permits and inspections. However, don’t hesitate to call a professional for help if you’d rather not do the work yourself; even with paying to have someone else do the work, the dollars gained through energy savings in upcoming years will be worth the expense. Your bank may be able to help, too. Ask about a low-interest loan designed specifically to cover the cost of your energy-saving projects, or consider a home-improvement loan to fund them. Some banks offer energy-efficiency mortgages, which take into account the reduced energy bills when improvements are made to homes. The Minnesota Housing Finance Agency (mnhousing.gov) also offers a Fix-Up Fund Loan for home improvements—even if you do the work yourself.

The payback from this investment will be apparent for many years in terms of increased comfort and safety and reduced energy use and the associated environmental costs.

How do I pay for it?

Although many energy-efficiency projects (caulking windows, weather-stripping exterior doors, or insulating water pipes) will cost just a few dollars, others (insulating exterior walls, air-sealing an attic, replacing a furnace, or adding storm windows) may cost considerably more. Many utility companies offer incentives on larger projects (furnace replacement, attic insulation, new refrigerator) by giving you a discount on energy bills or sending you a rebate check when the work is completed. Other utilities offer free or discounted services or products (like water-saving shower heads, CFL bulbs, or energy assessments). Contact your local energy utility or visit the Database of State Incentives for Renewables & Efficiency (dseiausa.org) for details.

Community nonprofits and neighborhood organizations offer a variety of services and programs, including energy assessments, energy education, free or discounted products, and financing. Contact your city or municipality to learn what is available in your area.

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Energy assessment tests can include scans from infrared cameras (at right) to pinpoint voids in insulation, air leaks, and moisture problems. Locating the leaks makes it easier to seal and make necessary repairs—and improves the returns on other energy investments you make.

Some Minnesota residents may be eligible for aid from the state Weatherization Assistance Program or Energy Assistance Program. Applications can be made through local service providers; go to mn.gov/commerce/industries/energy/service-providers/swap/ for eligibility requirements, application forms, and contact information.

Finally, for the latest information on tax incentives, rebates, or grant programs from federal, state, or local governments, check out their websites. It is important to find out the specifics (qualifying products, installation requirements, site analysis, inspections, etc.) before purchasing products or services. Some programs require qualified contractors, approved applications or specific products or procedures in order to qualify for the funding. Not meeting the requirements may jeopardize your incentive, rebate, or grant. A listing of many current programs and links is also available at our website: mn.gov/commerce.

ENERGY STAR®

ENERGY STAR® is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that helps save money and protect the environment through energy-efficient products and practices. Many appliances, lighting products, and electronics can earn the ENERGY STAR® label by meeting these energy-efficiency requirements:

• Qualified products must deliver the features and performance demanded by consumers, in addition to increased energy efficiency.

• If the qualified product costs more than a conventional, less-efficient counterpart, purchasers will recover their investment in increased energy efficiency through utility bill savings, within a reasonable period of time.

• Product energy consumption and performance can be measured and verified with testing.

When shopping for lighting, electronics, and appliances (including heating, cooling, and water heating), always look for the ENERGY STAR® label. To find qualifying products or to compare performance of several products that are ENERGY STAR® labeled, go to energystar.gov.
Simply speaking, the materials of a house that separate the outside from the inside are considered the home’s envelope. It is the barrier that keeps us from experiencing the extremes of the outside environment and keeps the inside of our home comfortable, dry, and energy efficient.

The home’s envelope includes windows, doors, walls, ceilings, and foundations. Each of these components consist of several elements that go together to create the structure. So, for instance, a wall-segment may consist of the interior paint, the drywall, the framing lumber, the air barrier and vapor sealing, the insulation, the exterior sheathing, the siding, and the exterior paint. Well-designed components work together to make the envelope as tight as possible.

**Home tightening**

Every home needs a certain amount of fresh air for the furnace and appliances that burn fuel, for getting rid of excess moisture, and for reducing odors and stuffiness. When this air exchange is controlled, it’s called ventilation. When it seeps uncontrolled through cracks and holes in the envelope of our home, it is called air infiltration. Air that leaks through the ceiling, walls, foundation, and other areas are significant sources of heating and cooling losses in a home – up to one third in some homes. Stopping air leaks is the best way to conserve energy, save money, and increase comfort. The bottom line: If you don’t tighten up your home first, other improvements (like windows, insulation, furnaces) may not be as effective.

**Infiltration through air leaks can occur in three ways:**

- **Wind-driven infiltration** happens during cold-weather months when the wind blows cold, dry air into a house through cracks and openings and forces warm air out. During warmer weather, the wind blows in warm, humid air, forcing cooler air out.

- **Stack-effect infiltration** takes place during the natural process of convection. As warm air rises and escapes through cracks at the top of the house, it pulls cold air into the lower areas.

- **Negative air pressure infiltration** starts when appliances use air for combustion or when ventilation fans are operated. Outdoor air enters through any available openings to equalize the pressure inside a home. This can be a problem if adequate fresh air for combustion appliances has not been provided. It can lead to a potentially dangerous carbon monoxide risk as fresh air is pulled down chimneys or vents, interfering with their proper operation.

Typically, air infiltration causes drafts and a chilly feeling near windows and doors and in basements. Adjusting your thermostat will not stop the drafts, but sealing hidden cracks and openings will. By stopping air leaks at their source, you’ll stay warmer in the winter and cooler in the summer, use less fuel, and reduce your utility bills.

**Where do you start?**

Fortunately, air infiltration is one of the easiest forms of energy loss to correct. The process requires only a careful inspection of your home and some inexpensive weather-stripping, caulking, and filler materials.

Most people know they should caulk and weather-strip around the exterior of their homes to protect it from the elements. However, it is equally important to protect your home from interior air leaks. Most interior air can enter the walls and ceiling through cracks and holes, and condensation buildup in those locations can damage or destroy insulation, wiring, wood, or other building materials.

**Look for air leaks**

Before research and building science demonstrated the role air leaks play in energy loss, most people assumed that insulation was enough to stop heat flow through a building. Although insulation slows heat transfer, it is easily compromised by air flow, whether driven by outside wind conditions or convection currents within the building. The only way to stop this air movement—and the associated heat loss—is by eliminating the holes and pathways between the inside of the house and the outside.

The first step to tightening up your home’s envelope is performing a detailed inspection for air leaks, including a blower door and an infrared camera scan. This should be part of every energy assessment, and the inspector should be able to show you locations where air is leaking and needs to be sealed. A good rule of thumb is to start by plugging holes and leaks in the attic; then move to the exterior walls, and look for smaller leaks around doors, windows, and electrical switches and outlets; finally check out your basement.

**Attic air leaks: more common than you’d guess**

Most existing homes have many unsealed penetrations into the attic for wires, chimneys, vents, etc. Sealing will prevent heat loss and damage to building materials.

**Hatches and doors to the attic**

Weather-strip the edges of the access hole and insulate the back of the attic hatch/door. Don’t forget doors to unheated knee wall areas.

**Holes in attic floor**

Seal all openings around electrical wires, pipes, ducts, and vents with a good general-purpose caulk or spray foam. You may need to use a filler material for larger holes.

### Recessed lights and bathroom fans

These fixtures can poke into the attic insulation and create a pathway for air leaks. Caulk around them from below with flexible, high-temperature caulk. Install an airtight box sealed over the top of them in the attic, not only to stop air leakage but to reduce fire hazard from insulation lying against the fixture. When replacing light fixtures, use only air tight fixtures.

**Chase for plumbing vent stacks**

This channel may run inside the walls of your home, from the basement to the attic, with openings at each floor where the lines branch off. If the chase isn’t much larger than the vent where it enters the attic, seal with expanding foam. For larger chases, use drywall, wood, or rigid foam—and caulk or foam around all edges.

**Fireplace chimney and furnace/water heater flues**

Close the gap between house framing and the chimney and vent flues with metal; seal with red fire-stop caulk.

**Knee-wall storage drawers**

If storage drawers are recessed into the attic space, build an airtight, insulated box around the backside of the drawers. Don’t forget to seal all joints with caulk or sheathing tape.

**Other holes**

Using the appropriate materials, seal all other holes between the heated space in your house and the attic.

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**Ceiling fixtures require proper air-sealing**

Light fixtures below an unheated attic must be tightly sealed to prevent air from leaking into the attic space. Attic air leaks not only waste energy, they are the primary cause of ice dams.

**Methods of sealing include:**

- **Recessed fixtures.** New or retrofit recessed fixtures (including new LED fixtures) should have airtight cans and gasket seals. Existing recessed lights can have special airtight boxes sealed over them from the attic side.

- **Flush-mount fixtures.** Electrical boxes should be sealed with spray foam around any cracks or openings into the attic. Caution: Disconnect power to circuit until foam cures!
Attic air leaks = ice dams
Although many years ago thought of as a problem with roofing or attic ventilation, ice dams are actually caused by the presence of warm, moist air in the attic, combined with snow on the roof and the right weather conditions. Ice dams occur when heat gets into the attic and melts the underside of the snow on the roof. The melted snow then flows down the roof surface until it reaches a cold spot (such as the eaves or soffit) where it forms a frozen dam, behind which more snowmelt and ice pile up. The ice buildup can back up under the shingles, damaging them and allowing water to leak to the ceilings and walls below.

What NOT to do:
• Installing heating cables will shorten the life of your roof and cost you money to operate.
• Removing the ice with chippers, chemicals, or heat can damage shingles, gutters, and other building components.
• Adding roof vents — including powered vents — will not eliminate ice dams, and often make the problems worse.
• Although additional insulation — especially higher density foam on the top plate of exterior walls — can reduce heat transfer to the roof deck, insulation alone is insufficient.

Air leaks can damage insulation and more
Water vapor carried with the escaping warm air may condense, freeze, and build up in the insulation. When this water builds up, it can soak the insulation (wet insulation has little insulating value), cause plaster and paint to crack and peel, and lead to rot and other structural damage.

Basement air leaks: easy to seal
Most basements have multiple air leakage locations. Because of the physics of the stack-effect (causing warm air to rise), basements are a common source of cooler air leaking in through cracks or penetrations in the foundation or unsealed joints where floor framing rests on the foundation wall. Air then rises through holes around chimneys, vents, wires, and plumbing into the rest of the house. Careful sealing will help to limit warm air entering the attic.

Sill plate and band or rim joist
 Caulk cracks between the sill plate and foundation wall using a masonry caulk, and fill cracks between the sill plate and band or rim joist. Then insulate the band/rim joist area by spraying with expandable foam or by cutting foam board insulation to fit and then caulking in place. Do not use fiber-glass, as it does not stop air infiltration and because moisture from the basement can get between the fiberglass and the rim joist, leading to mold and mildew.

Chase for plumbing vent stack(s)
Sealing the chase at the basement end, as well as the attic, will reduce the flow of air to the other floors in the house.

Chimney for furnace and water heater
As in the attic, close the gap between framing and chimneys with metal; seal the edges with red fire-stop caulk. Vents made of PVC (plastic) piping can be sealed directly with spray foam or regular caulking.

Hatch or door to crawl space
Weather-strip the edges and insulate the back of the hatch or door.

Openings through basement ceiling
Seal with caulk or foam the hole where the bathtub drain comes down and other holes for plumbing or electrical wiring in the basement ceiling. You may need to use filler material for larger holes.

Basement windows
Using a masonry caulk or spray foam, fill cracks where the frames of the windows are set into the walls. Windows that are not used for ventilation or as fire exits can be caulked shut permanently.

Ducts
In homes with air ducts, there may be gaps where ducts pass through ceilings, floors, and walls. Caulk or foam where the metal duct and the ceiling, floor, or wall meet.

Other holes
Seal cracks or holes in the foundation with caulk, foam, or the appropriate patching material. Don’t forget to check where the electrical, gas, water supply, telephone, and cable lines enter the house, and seal on the inside and outside.

DON’T SEAL COMBUSTION AIR SUPPLIES!
Water heaters or furnaces may have a flexible duct that supplies fresh air for combustion. *These must be kept open!* A “J” loop near the duct end can reduce cold air in the basement.

Interior sealing: plug the holes around you
Air leaks in the occupied part of your home are the ones you are most likely to notice. The drafts of air infiltration can be felt around windows, doors, outlets, and fireplaces. The results of these air leaks can frequently be seen as condensation or frost buildups on windowsills or the bottoms of doors.

Window and door frames, trim, and baseboards
• Carefully remove trim and caulk or foam the gap between the wall framing and the window or door jamb. Don’t use fiberglass insulation, it doesn’t air-seal. If you are unsure how to properly remove and replace the trim, consider hiring someone qualified to do it.

Seal pipes, vents and ducts
There are many places that air can leak into a basement (left). Gas, electric or water lines and vents for dryers, exhaust fans, or high-efficiency water heaters or furnaces that exit through foundation walls or rim joists should be caulked or foamed to prevent air leakage (center). Furnace ducts that rise from basements through floors or walls should be sealed where the metal meets the wood framing (above).
AIR-SEALING

**VENTS FOR FURNACES, DRYERS, WATER OR FOAM TO WEATHER SEAL THE EXTERIOR OF**

There are many places to apply caulking switches can increase comfort, avoiding plaster. And foam gaskets on outlets and them up with caulk, weather-stripping, or floors. Note: caulk on wall/ trim may be a challenge when repainting.

**MISSING PLASTER, CRACKS**

Exposed laths indicate a direct hole into wall and ceiling cavities. Repair with plaster or cover with drywall. Repair smaller cracks using patching material, and repaint.

**WINDOWS AND DOORS**

Check the weather-stripping on all windows and doors, and repair or replace as necessary. Check the threshold on doors, and replace if worn or leaking air. Replace broken glass and replace or putty loose windowpanes. Caulk around moving parts of windows with nonpermanent caulk that can be removed easily. You can also install inexpensive window films (inside only) to cut air leaks.

**ELECTRICAL OUTLETS AND OUTDOOR PLUGS**

Install foam gaskets and child-safety plugs on all switches and outlets—even on interior walls. Although this may have a very small effect on heat loss from air infiltration, it can have a noticeable effect on comfort, by reducing drafts.

**OTHER HOLES IN EXTERIOR WALLS**

Caulk or foam around all ceiling fixtures, heat registers, medicine cabinets, bathtubs, kitchen cabinets, drains, and water pipes where they enter the wall in the kitchen and bath. Also seal any other holes in exterior walls.

**Exterior caulk**

Sealing on the outside of your home not only prevents air from entering, it can also prevent damage to siding, windows, insulation, windows, and doors due to moisture intrusion.

**HOLES FOR PIPES, WIRES, ETC.**

Caulk or foam around openings for electric, gas, oil, and water-supply lines; drainage pipes; plumbing for outside spigots; cable TV and telephone cables; mail slots/doors.

**VENTS**

Caulk or foam around dryer vents, heating and cooling system vents, and fresh-air supply vents for fuel-burning furnaces and water heaters.

**WINDOS**

Caulk around window frames. If you have combination storm windows, caulk where the metal storm window frame meets the window’s frame; don’t seal the moisture weep holes at the bottom of the frame. If you have wooden storm windows that must be exchanged for screens in the spring, use non-permanent, non-staining rope caulk to seal the joint between the storm window and the frame.

**DOORS**

Caulk around door frames. Install storm doors if needed and check latches and seals.

**FIREPLACES:**

**WASTE MORE HEAT THAN THEY MAKE?**

A charming old wood-burning fireplace may seem warm and cheery, but it likely loses more heat from your home than it gives off. Warm air in a home is sucked up the chimney and is replaced by cold air leaking into the house. Especially as the fire dies down, more heat is drawn up the chimney than is created by the fire—and the reduced rate of airflow can lead to backdrafting of dangerous flue gases and smoke into the living space.

Follow these tips to improve the operation and safety of your fireplace and to reduce your energy losses:

- Improve the seal of the flue damper. To test the damper’s seal, close the flue, light a small piece of paper, and watch the smoke. If the smoke goes quickly up the flue, there’s an air leak. Seal around the damper assembly with refractory cement, but don’t seal the damper closed.
- Install tight-fitting glass doors or an air tight/airproof fireplace insert unit. Controlling the airflow in your fireplace improves combustion efficiency by 10 to 20% and reduces air leaks up the chimney. When there is no fire or embers, close all vents and dampers tightly.
- If you infrequently use the fireplace, install an inflatable “chimney balloon” in the flue of the chimney to reduce heat loss. These are available in several sizes and, if properly installed, can significantly reduce heat loss through the flue. Most have a quick-release handle and many have a safety feature that will instantly deflate the balloon if a fire is started without removing the balloon.
- Many fireplaces and stoves have a source of fresh air to aid in combustion—in fact it is required for most new installations. Fresh air supplies should have a well-sealed damper to prevent air leakage when not in use.
- The joint where a brick or stone chimney meets the wall or ceiling can be a source of air leakage. Foam or caulk to prevent unwanted airflow.

**Caulking is easy and cost-effective**

Use caulk to permanently seal air leaks in spots such as the cracks and gaps between exterior window and door frames and your home’s siding. Generally speaking, you can seal openings up to ½ inch with caulk alone. For larger gaps, you’ll need to add a backing material before caulking or use a spray foam sealant instead.

Older wood windows may have glass panes that are held in place with putty and glazing points. If the putty is cracked or missing, it is a likely air leakage location and must be re-puttied. (Broken panes should be replaced.) Although caulking may be used to repair/replace window putty, it may be difficult to apply neatly and may make future repairs a challenge.

When shopping for caulk, you may be overwhelmed by the choices, so be sure to read the labels and choose the caulk that will work best with the materials you’re sealing. The two basic types are latex and silicone, and each have advantages, depending on the circumstances. Most caulk is sold in tubes that fit a caulking gun; some are available in plastic squeeze-tubes. In addition, some caulks come in aerosol cans; they’re a good choice for filling gaps up to ½ inch. Note that some caulks are for indoor use only, and that some are paintable—while others are not.

The benefit of high quality caulk will be a longer-lasting seal; inexpensive caulks may last only a few years.

Before caulking, note the following points:

- Remove old caulk and loose materials completely.
- Make sure all surfaces are dry and free of dirt, grease, or oil; wipe with rubbing alcohol to clean.
- Check caulk instructions for application temperature and don’t apply when rain is possible before caulk has cured.
- Tape the edges of the crack to keep caulking off adjoining surfaces.

Follow these tips to get a neat, uniform bead of caulking:

- Cut the nozzle at a 45 degree angle at the point where the diameter is equal...
to the size of bead you need—near the end for a small bead, farther up for a wider one.

- While applying constant pressure on the trigger, hold the gun at a 45-degree angle and move it slowly along the joint you are sealing.
- Make sure you have enough caulk in the joint to seal both edges and allow for any shrinking.
- Smooth the caulk with a plastic tool. Once you have applied the caulk, it takes time for it to dry, or cure. Curing time is described two ways. The tack-free time tells you how quickly the fresh caulk’s outer surface will dry—or skin over. The total cure time indicates the time required for the caulk to become completely stable—or reach the point where no further drying or shrinking will occur.

Most caulks pose no known health hazards after they’re fully cured. However, some high-performance caulking compounds contain irritating or potentially toxic ingredients, and you should apply them only when there is adequate ventilation; carefully read the manufacturer’s instructions and take the appropriate precautions. In addition, make sure pets and people do not come into contact with fresh caulk.

**Use spray foam for large gaps**

- Expanding foam is ideal for filling larger cracks that caulks can’t handle. It comes in aerosol cans and takes a short time to cure. The foam is very sticky and attaches itself quickly to whatever it touches, so be prepared to pick up any messes fast.
- You also can use foam instead of caulk for sealing in your attic; low-expansion foam will stick better to dusty and dirty surfaces than caulk.
- Low-expansion spray foam should also be used to seal the space between framing and jambs in windows and doors; standard expanding foam can cause jambs to warp and affect operation of the window or door.
- When you’re working in a large area such as your attic, it may be inconvenient to carry and keep track of several cans of expanding foam. Instead, consider renting a contractor’s foam gun, which has a long nozzle and can help you get into tough-to-reach spaces.

**Try these materials for special jobs**

In addition to the types of caulk and spray foam sealant described above, you may need to use fillers to plug extra-wide gaps. Fillers come in a wide variety of materials—cotton, fiberglass, foam, and sponge rubber—and you can find them in the caulking department of your local hardware store or home center. However, these fillers are not designed for exposure to the elements; you’ll need to caulk or seal over them.

- To close gaps too wide for foam, cut sections of rigid foam insulation to fit and glue into place with expanding foam—before covering with wood or another appropriate building material.
- For winter, use rope caulk to seal windows and other spots that you’ll want to be able to open during the spring. Rope caulk is a gray, putty-like material that comes in long strips or rolls. It’s easy to install and remains flexible, and you can just pull it off when the weather turns warm. Note that rope caulk will not last longer than a year, and oil-based rope caulk may stain painted areas.

Keep heated and cooled air in ducts

The ducts for a forced-air heating and air-conditioning system can be one of your home’s biggest energy wasters, especially if those ducts run through unheated or uncooled spaces (like attics or crawl spaces).

Properly sealed ducts can deliver heated or cooled air where you need it, instead of leaking out where you don’t. This allows your furnace/air conditioner to work less to make you comfortable.

- Check the ducts for air leaks, including around the filter cover. Repair leaking joints first with sheet-metal screws; then seal joints with either latex-based mastic with embedded fiberglass mesh or metal/foil tape (UL 181). Don’t use plastic or cloth duct tape because it will harden, crack, and lose its adhesion.
- Wrap ducts in attics/crawl spaces with special duct insulation. Seal all insulation joints with the appropriate tape.
- Make sure ducts fit tightly to the register openings in floors and walls; if they don’t, seal them with caulk.
- Seal return ducts, too, so you won’t be breathing basement or crawl space air.
- Make sure registers and baffles are adjusted properly to distribute heated and cooled air to where you need it. For example, in the winter close registers in unused rooms.
- Don’t confuse duct-sealing with duct-cleaning! There are no energy-related benefits to duct-cleaning.

**Steps to caulking**

Laying a consistent bead of caulking can take some practice. Follow these steps to provide a good seal:

- Insert tube into gun.
- Cut tip at 45-degree angle at desired thickness; use wire/nail to break seal at base of spout.
- Squeeze trigger while moving tip steadily along joint to be filled.
- Smooth bead with tool or gloved finger, making sure both edges are covered.

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Insulation slows the heat flow through a building’s envelope. It works year-round to make your home more comfortable and energy efficient. In the winter it slows heat loss and in the summer reduces heat gain and helps keep your home cool.

Adding insulation to your home can cut heating and cooling costs 15% or more, depending on factors such as the amount of existing insulation in your home, house size, air leaks, personal energy use, and living habits. Many variables affect the exact amount you’ll save, but installing insulation is your home is usually a wise energy investment.

While every house is different, the basic rule of installing is the same for all homes: Install insulation on any surface separating a heated space from an unheated space. Even if your home already has some insulation in these areas, there can be great benefits in adding more insulation, especially in your attic.

Recommendations vary for the amount of insulation necessary in particular locations for peak energy savings, depending on factors such as climate conditions, the sections of your home being insulated, and the kinds of materials used in your home’s construction.

Insulation is rated by R-values

The R-value (or thermal resistance) of insulation is based on its performance with no heat gain and helps keep your home cool.

Benefits in adding more insulation, especially in your attic.

Start in the attic

You can lose a significant amount of heat through the top of the attic to the attic floor. A-frame house or flat roof is an especially difficult job, because there is little or no space between the ceiling and roof. One option is professional installation of spray-in insulation materials; alternatively, building out of roof rafters to allow additional insulation is also possible. A third option is to have foam insulation applied beneath the roof deck during a re-roofing project. All options also must provide ventilation to current code.

Insulating the “story-and-a-half”

Many homes built in the middle of the 20th century were single-story with a large “expansion attic” above. These areas frequently became finished living space — and were often uninsulated or insulated improperly. Because of the complexity of the framing and the difficulty gaining access to some of the areas that need to be insulated, the story-and-a-half can present an insulation and air-sealing challenge. But, considering that so much heat can escape through the top of a building, proper air-sealing and insulating of these structures is essential.

If the attic space has never been framed or finished, insulating and air-sealing can follow the standard practices as if it were new construction. If, however, knee walls and ceilings are in place, special care must be taken to ensure a good result. (Note that the same approaches to sealing and insulating also apply to homes that have an attic above a second floor — a “two-story-and-a-half.”)

Four surfaces must be sealed and insulated

There are four parts to a typical story-and-a-half framing system (along with the vertical gable ends). Each part requires a different approach for proper air-sealing and insulation.

Ceiling

The flat ceiling is similar to an attic floor. Batt or blown-in insulation can be installed between and over the ceiling joists. Access to the space may be through an attic crawl space or through roof vents. If the knee wall space is unheated, baffles must be installed for ventilation. Air-sealing of all penetrations (access doors, wires, fixtures, vents) must also be done.

Slants

The slanted part of the wall should be treated like a cathedral ceiling. Building out the rafters to allow for additional insulation and ventilation is the best solution. Professional installation of a spray foam is also possible, as well as rigid foam under the roof decking. If the space behind the knee wall is to be kept as heated storage, the insulation needs to extend all the way to the floor along the slants.

Walls

The vertical walls (knee walls) can be insulated and sealed just like vertical walls on the lower part of the house, with the following exceptions:

• If the knee wall space is heated storage, no knee wall insulation is required (see slants, above).
If the knee wall space is heated storage, no floor joist insulation is required. Other -glass. Air-sealing of all penetrations (access doors, outlets, wires, vents) must also be done. If there are built-in draw- ers or cabinets, a sealed and insulated box must be built around them on the knee wall (cold side).

Floor
The space between the floor joists beneath the knee wall is often neglected in terms of insulation and sealing—and is often the most difficult to access. If the knee wall space is heated storage, no floor joist insulation is required. Other- wise, insulation must be installed beneath the floorboards from the outside junction with the roof to a point beyond the knee wall. The methods include:

- Removing floorboards to place batts between the joists. A “plug” of gypsum or foam insulation board should be installed beyond the knee wall, caulked or foamed to prevent air leaks.
- Drilling holes in the floorboards to install dense-packed cellulose insulation. Because dense-packed cellulose pro- vides an air barrier, no additional air-sealing is required.

Head for the basement
Most Minnesota homes have basements with either concrete block or poured-concrete walls. While these make sturdy foundations, they’re poor insulators and have a very low R-value. Therefore, an uninsulated basement can account for a significant amount of a home’s energy loss.

Check the top of the basement foundation
The wooden rim (or band) joist area—which is the house’s wooden structure rests on the concrete foundation—is the best place to begin. It’s the simplest and least expensive base- ment area to insulate, and it will bring you the highest return on your investment. And, because it is usually above ground, there is little risk of moisture migration from the exterior.

Insulate with cut-to-fit pieces of rigid, extruded polystyrene or polyisocyanurate foam, caulked or foamed into place, to avoid air leaks. Fiberglass is not recommended because it does not provide an air-tight seal. Moisture from the basement can migrate through the fiberglass where it condenses on the cooler rim joist, leading to potential problems with mold or wood rot.

Insulating the foundation walls
Concrete (whether block or poured) is extremely porous, and unless sealed from the outside, it is a likely source of moisture into a basement. Because migrating and condensing moisture can be trapped behind wall insulation—leading to mold and mildew growth—insulating basement walls is challenging. Even historically dry basements can be subjected to water migration or seepage during severe storms or flooding. (Don’t be misled by claims that products are painted or applied to interior basement surfaces will prevent moisture from seeping through walls or floors—they can’t.)

Attaching wooden studs to the foundation wall and install- ing fiberglass insulation (a method used in previous years) is no longer recommended. The wood and insulation can become a good medium for growing mold and mildew when moisture finds its way between the foundation wall and the insulated wall.

Interior basement walls—that have a very low risk of mois- ture potential—can sometimes be insulated successfully with rigid foam panels; proper assessment and installation by a professional contractor is strongly suggested, however.

Attention to details—such as proper sealing—can reduce the chances of damaging mold and mildew problems. It is important to note again, however, that foundation walls that are not sealed from the outside will potentially allow mois- ture to migrate into the basement.

Unfortunately, the recommended approach to basement insulating can also be costly: removing the soil outside the house all the way to the footing, sealing the foundation wall, providing for proper drainage, then insulating with rigid foam on the exterior of the wall. An alternative approach uses a high pressure sprayer to remove soil from alongside the foundation wall. The resulting narrow trench is filled with a specially formulated spray foam that provides insula- tion as well as moisture control. A project of this magnitude requires hiring an experienced contractor.

Insulate floors over unheated spaces
Floors over a basement that have a heat source such as a furnace, boiler, or wood stove don’t need to be insulated. However, floors over an unheated area such as a garage, a porch, or open ground can be a source of considerable heat loss. Window projections (such as bay or bow windows) also need to be insulated and sealed where they protrude from the surrounding wall. Some homes (especially older) may not have had adequate insulation or air-sealing at these locations. A professional insulation contractor can often access these challenging locations:

- Cantilevered floors over an exterior wall can be sealed and insulated with spray-in polyurethane, polyisocynane, or blown-in cellulose insulation through small holes on either the interior or exterior. Air-sealing of joints and cracks (with spray foam and other products) is critical to prevent moisture from damaging insulation or building components.
- Bay or bow windows can be insulated with rigid board insulation or spray-in foam at the “floor” and the “roof” of the projection.
- Tuck-under garages are particularly important to air-seal and insulate. The risks of fumes (from vehicles or things stored in the garage) migrating into the house above can be significant. Sealing all joints and cracks with spray foam and then applying rigid foam insulation covered with gyp- sum board is a good option.
- Slab-on-grade homes that were not insulated properly during construction can sometimes have rigid insulation board with plywood flooring installed over the slab.

Insulation Options

Basement Insulation Options

The best way: exterior
Although usually more costly (in an existing building), the insulation of founda- tion walls from the outside is the best way to provide thermal efficiency and protection from moisture problems, mold, and mildew. Proper sealing and drainage are important in any exterior foundation insulation project.

From the inside—usually not a good idea
Because of the risk of mold and other moisture problems, the insulation of interior basement walls is very challenging to do prop- erly. Unless basements have a very low risk of moisture potential, it is better to leave the walls uninsulated on the interior to allow drying and reduce mold and mildew issues.
If you have a crawl space ...

Any part of the house that is heated must be separated from unheated space by insulation and air-sealing, including crawl spaces. If your crawl space has a dirt floor, cover it with polyethylene sheeting before insulating and extend the plastic several inches up the walls. As with a basement foundation wall, the preferred method for insulating is from the outside. Other options include:

• Insulate crawl space foundation walls and the floor to a value of R-10 or higher with a rigid foam insulation, appropriately sealed.

• Insulate between the floor joists with sprayed foam or rigid foam to a minimum of R-10. (Because of the difficulty of a proper air-sealed installation, fiberglass batts between the joists is not usually recommended.)

Regardless of the method used, crawl space ventilation is not recommended, due to moisture and condensation concerns.

Check out your walls

Generally speaking, homes built before 1960 do not have insulated walls, or are insulated with products that are inadequate by today’s standards. Even some homes built after that were not carefully or completely insulated. The benefits of adding insulation to exterior walls can be very high, depending on the situation. There is a simple way to determine whether your walls contain insulation: Turn off the electricity and remove an electrical outlet or switch plate on an exterior wall. Then turn on the electricity. If your walls contain insulation: Turn off the electricity and remove an electrical outlet or switch plate on an exterior wall. This will tell you only whether or not you have any insulation. If the outlet doesn’t work, you have insulation. If the outlet does work, you don’t have insulation. This is the best way to determine whether or not you have any insulation in your walls. If you have any insulation, you can use a vapor retarder and an air-sealing material to make your walls more energy-efficient.

When should you add wall insulation?

Insulating your walls may be a good idea when there is less than one inch of insulation in the wall cavities (typically, walls have space for 3½ inches of insulation) or if infrared imaging reveals significant voids or gaps. If remodeling work is planned involving exterior walls, adding wall insulation (and proper air-sealing) is relatively easy and affordable.

Fiberglass batts

If wall cavities are accessible from the inside (because plaster or gypsum has been removed), installing fiberglass batts is relatively straightforward. Careful cutting and fitting around wires, electrical boxes, pipes, and vents is very important. When fiberglass is compressed, it loses significant insulating value; when “bunched up” (around wires, for example) there can also be voids and gaps. Insulating a vapor retarder over the fiberglass is also important; seal all seams with sheathing tape. Outlets and switches should have an air-tight box installed that is taped or caulked to the vapor retarder.

Dense-pack cellulose

Drilling small holes (from the inside or outside) and adding dense-pack cellulose can provide good insulating value, and excellent air-sealing as well. Installed by an experienced contractor, dense-packing sidewalls also requires patching and finishing the access holes (which can be a challenge with exterior finishes).

Other wall insulation options

• Removing old siding and installing new siding provides several insulation options. Dense-pack cellulose can be blown into empty stud cavities through holes in the exterior sheathing before the new siding is installed.

• Additional wall insulation can be added to the exterior wall of your house without removing existing siding. This is often the most cost-effective way to insulate sidewalks in homes with no existing wall insulation.

Insulation needs a vapor retarder

As with a glass of ice water, condensation occurs when warm, moist air touches a cold surface. When this happens in your home, it can cause mold, mildew, and damage to building materials and reduce the effectiveness of the insulation. A vapor retarder slows the movement of air and water vapor through building materials; in fact, a good vapor retarder will allow very little moisture to pass through. Some vapor retarders also serve as air barriers. A good vapor retarder and good air-sealing can improve the energy-related performance and durability of your home.

Most homes built before 1970 do not have a separate vapor retarder component; however, the predominance of oil-based paints in those homes usually provides an adequate vapor control function.

Whenever you install insulation, always include a vapor retarder. If you’re adding insulation to an area that already has a vapor retarder, you do not need to add another one. Vapor retarders include:

• Polyethylene sheets are most frequently used as a vapor retarder, but they may not be a good choice if you have central air conditioning; hot, humid outside air can be driven through the wall assembly and condense in the cooler wall cavity, leading to potential moisture problems.

• Foil or kraft paper often is part of fiberglass batt or blanket insulation. The vapor retarder should face the interior of the building.

• Most rigid foam board insulation acts as a vapor retarder when installed under an interior covering material such as drywall. If the foam is also intended to be an air barrier, the seams should be taped — for both interior and exterior use — to improve its performance.

• Sprayed-in foams (such as polyurethane insulation) may not need a vapor retarder when installed properly. Check your local building codes for vapor retarder requirements with spray foams.

• “Smart vapor retarders” are a relatively new product that allows moisture to migrate out of a wall cavity under certain conditions. Consisting of a film that is applied over un-faced fiberglass or other insulation (similar to polyethylene sheets), smart vapor retarders have a high resistance to water vapor under low-humidity, winter conditions, thus slowing moisture movement from the inside environment into the wall. During high-humidity, summer conditions, the permeability adapts, thus permitting any trapped moisture in the walls to migrate to the interior.

• Finally, vapor retarder paint (often a primer sealer) can provide adequate vapor control and can be applied to new or previously painted interior surfaces.

Wall insulation

Fiberglass batts (right) can be applied if walls are opened to the interior. Care must be taken to not compress or leave voids in the insulation in order to maintain thermal performance. Penetrations (such as wires, electrical boxes, pipes) must be carefully sealed with caulkings or spray foam to prevent air leakage.

Dense-pack cellulose (made from recycled newspapers) is an excellent choice for insulating and sealing walls (left). Installed through holes drilled from either the outside or inside, it is often the most cost-effective way to insulate sidewalks in homes with no existing wall insulation.
Types of insulation

Insulation does its job by creating small pockets of air that slow the transfer of heat through the insulation—in exactly the same way that a blanket works. Types of insulation vary according to use and location. Among the insulation options that work best in Minnesota’s cold climate are the following:

### Batts or blankets

<table>
<thead>
<tr>
<th>Material</th>
<th>R-value/inch</th>
<th>Method of installation</th>
<th>Where applicable</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber glass, rock (mineral)  wool</td>
<td>3.1 to 4.0</td>
<td>Fitted between studs, joists and beams.</td>
<td>All unfinished walls, floors and ceilings.</td>
<td>Do-it-yourself. Suited for standard stud and joist spacing that is relatively free of obstructions.</td>
</tr>
</tbody>
</table>

### Loose-fill

<table>
<thead>
<tr>
<th>Material</th>
<th>R-value/inch</th>
<th>Method of installation</th>
<th>Where applicable</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulose, fiberglass, rock (mineral)  wool</td>
<td>2.4 to 4.0</td>
<td>Blown into place (attics) or dense-packed (cellulose, walls).</td>
<td>Enclosed existing wall cavities or open new wall cavities. Unfinished attic floors and hard-to-reach places.</td>
<td>Do-it-yourself. Suited for standard stud and joist spacing that is relatively free of obstructions.</td>
</tr>
</tbody>
</table>

### Rigid foam

<table>
<thead>
<tr>
<th>Material</th>
<th>R-value/inch</th>
<th>Method of installation</th>
<th>Where applicable</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extruded polystyrene foam (XPS), expanded polystyrene foam (EPS or beadboard), polyurethane foam, and polyisocyanurate foam</td>
<td>3.5 to 7.5</td>
<td>Interior applications—must be covered with ½-inch gypsum board or other building-code approved material for fire safety. Exterior applications—must be covered with weatherproof facing.</td>
<td>Basement rim joists, exterior walls under finish materials and vented low-slope roofs.</td>
<td>High insulating value for relatively little thickness. Can block thermal leak when installed continuously over frames or joists. Can provide both air barrier and vapor retarder.</td>
</tr>
</tbody>
</table>

### Spray foam

<table>
<thead>
<tr>
<th>Material</th>
<th>R-value/inch</th>
<th>Method of installation</th>
<th>Where applicable</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyurethane, polyisocyanene</td>
<td>3.6 to 7.0</td>
<td>Sprayed onto surfaces or behind a net facing.</td>
<td>Open wall cavities, between roof rafters.</td>
<td>High insulating value for relatively little thickness. Provides good air barrier. Some products provide vapor retarder.</td>
</tr>
</tbody>
</table>

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## Windows, doors, and skylights are often a weak energy link in home construction, accounting for a significant portion of a home’s heat loss in the winter and heat gain in the summer.

Many complaints about condensation or frost on windows and doors and about drafts or temperature discomfort in a house are actually caused by air leaks. Although new technology has greatly improved the energy efficiency of modern products, any fenestration (an opening, such as a window or door) will be far less efficient than the surrounding wall structure—especially one that is properly insulated and air-sealed. Because new windows and doors are relatively expensive, it is important to determine when repairs make sense and when replacement is the right choice.

### When to repair windows and doors

As homes age, building materials age as well, losing strength, flexibility, and usability. This disintegration process can be slowed considerably, and—surprisingly to many people—replacement of windows and doors may not be necessary if the problems are not structural. Simple maintenance and inexpensive repairs (like caulking, weather-stripping, and painting) can extend the life of windows and doors considerably—and for much less than the cost of new components.

Many older homes have windows and doors that were installed to the standards of their day; as building knowledge has improved, so have the components and methods of installation. Even relatively new products can suffer from inadequate materials or poor installation, however. Here are some common window and door problems and fixes:

- **Damaged components.** Cracked or missing panes of glass in doors or windows are obvious locations for leakage and energy loss. Replacement is best, but sealing with caulking can be a good temporary fix. Older windows may use a glazing compound (putty) to hold the glass to the frame. As this ages it dries and comes loose, allowing air to leak through, and should be replaced. Other damaged parts may be able to be repaired with wood putty or epoxy.

- **Defective air-sealing.** The gap between jamb and framing may be empty or stuffed with fiberglass insulation. Gently removing inside trim will reveal this space, allowing for application of a window and door spray foam product or caulking. Re-siding, access to this space may be possible from the exterior. If access to the space is difficult, a small bead of paintable caulking can be applied to the joint between the trim and the wall. A quick and inexpensive (but single-season) solution for leaky windows can be the application of shrink-wrapped film on the inside.

- **Loose or missing hardware.** Latches, hinges, and the operating parts for crank-out windows can become loose or damaged through repeated use. Often a simple tightening of screws will...
In addition, since all weather-stripping materials such as polyurethane, mylar, neoprene, and EPDM rubber are ideal for Minnesota’s climate because they remain flexible under temperature extremes.

As with windows, weather-stripping of doors is important, especially since most doors are opened and closed more frequently than windows. Materials such as polyurethane, mylar, neoprene, and EPDM rubber are also recommended for doors.

Special attention should be paid to the threshold seal at the bottom of the door; subject to considerable wear from foot traffic, it should be durable and flexible.

In addition, since all weather-stripping will eventually need to be replaced, it is important to have materials that are easy to remove and install and are readily available.

do the trick. If parts are bent or damaged, replacements may be available from the manufacturer or from a local building supply store.

• Improper exterior flashing. Properly installed flashing diverts water to the outside of the siding, preventing intrusion into the wall or window/door unit. Water that seeps into the wall cavity or structural components can lead to rot and voids, which can permit air to leak around the window or door. If water damage has occurred, removal of the exterior trim (and perhaps siding) and re-doing the flashing is the only way to remedy the problem. If damage to wall assemblies or insulation has occurred, repair and replacement may also be required.

• Worn or damaged weather-stripping. Weather-stripping prevents air infiltration around windows and doors by sealing the gaps between the frames and moving parts when they’re closed. With weather-stripping, one or both surfaces of a door or window must be free to move—as opposed to caulking, which builds a permanent seal between two stationary surfaces. Attention to detail is critical when installing weather-stripping in order to avoid problems with window and door operation. Along with windows and exterior doors, you should also weather-stripe all doors that lead to uneathed areas, such as the attic, garage, or unheated basement.

Types of weather-stripping
Weather-stripping comes in several sizes and shapes (often designed for specific uses) and may be made from metal, plastic, vinyl, rubber, felt, or foam—or a combination of these materials. Extensive testing has shown that tubular weather-stripping provides the best seal. However, on doors or swinging windows, this type requires the most closing pressure, which may be difficult for children, the disabled, or the elderly. Silicone, neoprene, urethane, or rubber strips are better in these situations. Open-cell foam and felt strips need to be very tightly compressed to create an adequate seal. They will keep out dust, but are inadequate air barriers. Therefore, the installation of neoprene, urethane, silicone, or rubber weather-stripping is recommended, because these materials create good air-seals with minimum closing force at all temperature ranges and have long, useful lives.

Many window and door manufacturers have replaceable weather-stripping kits that can be ordered and easily installed; check with the manufacturer or your building supply store for information about which specific units.

You can also buy weather-stripping by foot or in kits at a local hardware store or home center. You can calculate the amount of weather-stripping you’ll need by measuring the perimeter of all the windows and doors to be weather-stripped. It’s a good idea to add five to ten percent more for waste. However, before you buy anything, determine what kind of weather-stripping you want to use. If possible, remove a small portion of the existing weather-stripping (or take a picture) to compare it with what is available. Checking the size of the gap between the fixed and moveable sections of your doors and windows, as well as thinking about the amount of expected wear and tear in these areas, will help you decide which material is the most appropriate.

When to replace windows and doors
At some point, repairs may be too costly or time-consuming and replacement may make more sense. But, before you invest in a complete replacement of all components, consider some less-expensive alternatives:

Replacement window sashes. Older, double-hung windows can have new sashes installed that are multiple-paned and tightly sealed. The window frames remain, and new jamb inserts are installed to accept the new sash units. This approach may not require the removal of interior or exterior trim, and provides an opportunity to seal and insulate all around the unit.

Replacement storm windows and doors. Aged, damaged, or poorly made storm windows and doors can allow air leakage directly onto the main unit, reducing its thermal performance. Replacing the storms can be considerably cheaper than all new windows and can provide good air leak control as well.

Interior window coverings. Although drapes and blinds are important for reducing solar gain during the summer, specially designed interior window coverings are not considered as important for winter energy saving as they were a few years ago. Because they keep much of the warmer room air from the glass surface, condensation from small air leaks can cause frost buildup which can lead to component damage.

Interior panels. Sometimes thought of as “inside storms,” these consist of glass or acrylic panels that are custom-sized for each window. Some are designed to be installed in the fall and removed in the spring (like much interior storms) and others have a permanent mount with an operable sash. Because of the considerable risk of condensation and damage to the main window unit and components, proper installation and air-sealing of interior panels is essential.

Interior films. Interior plastic films (“shrink wrap”) are an inexpensive way to eliminate air leakage around windows. These products use pressure-sensitive adhesive tape to fasten the film to the exterior moulding or sometimes parts of the frame. Installed in the fall and removed in the spring, interior films are effective and can be installed by most homeowners and renters to reduce air infiltration.

What to look for in new windows
If damaged beyond repair or if there are cosmetic reasons for replacement, it may be time to purchase new windows. Buying windows, however, can be confusing. There are multiple options available, including the materials used in the frames, the finishes, the types and quantities of insulating and sealing materials, coatings, and more. But for evaluating energy efficiency, there are some basic things to look for:

The NFRC label
The first thing you should look for is a label from the National Fenestration Rating Council (NFRC). The NFRC is a nonprofit organization that provides consistent energy and performance ratings of windows, doors, and skylights. It evaluates products according to several categories, including:

• U-factor: The ability of a window to conduct heat (the inverse of an R-value, used to evaluate products like insulation). U-factor ratings generally fall between 0.20 and 1.20; the lower the number, the better the energy efficiency of the unit. The recommended U-factor for windows is 0.30 or less.

• Solar Heat Gain Coefficient: Measures a window’s ability to reduce heat gain in the summer, thus reducing cooling loads. Based on a zero to 1 scale, a lower number will reduce solar gain. In Minnesota, a good balance of about 0.50 is recommended.

The ENERGY STAR® label
The U.S. Department of Energy and Environmental Protection Agency have developed an ENERGY STAR® designation for products meeting certain energy performance criteria. Since the energy performance of windows, doors, and skylights can vary by climate, product recommendations are given for specific climate zones.

The National Fenestration Rating Council (NFRC) and its member companies together have developed a consistent, thorough, and independent assessment process of windows and doors that meet ENERGY STAR® standards. This label is the only one that can be trusted to meet ENERGY STAR® standards. The ENERGY STAR® label signifies that a product meets the ENERGY STAR® criteria, and is verified by the National Fenestration Rating Council (NFRC).
Proper window & door installation is critical to good performance

As with any product, proper installation of doors and windows will provide the best performance. That means suitable insulation and air-sealing between framing and units, and correct flashing on the exterior to prevent water intrusion.

To ensure warranty coverage, manufacturer’s instructions must be carefully followed, as well as applicable building and energy code requirements.

Remember, a gain in efficiency can be quickly negated by substandard installation or lack of attention to detail. In other words, buying windows and doors will provide the best performance. That means suitable materials and finishes available (above). Check the NFRC label for information about efficiency and performance.

Window features

Several features contribute to the ENERGY STAR® and NFRC ratings, including:

• Multiple glazings. Generally, the more panes of glass (or glazings) the better the insulating quality of the window. Double-pane windows are the standard in new windows; triple-pane units are used in certain applications (large or fixed windows, for example) to improve thermal performance.

• Gas filling. The space between the glazings can be filled with inert gases (such as argon or krypton) that are better insulators than air.

• Low-e coatings. Adding a metallic coating to the glass layers can lower the window’s ability to transfer heat.

• Insulating spacer. The material that separates the panes of glass can also conduct heat. Wood or other insulating material is better than metal.

Sash and frame construction

Important to the air leakage and U-factor of a window, the materials that compose the sash and frame also have an effect on maintenance and durability.

• Solid steel and aluminum. Although durable, these materials are poor insulators and have higher rates of expansion and contraction, making weather-stripping and caulking joints more prone to failure.

• Wood. A traditional material, wood is a good insulator and has much less expansion and contraction than other materials. However, wood is susceptible to moisture damage and requires more maintenance.

• Vinyl. Nearly maintenance free and similar to wood in insulating value, vinyl has higher expansion and contraction than wood. It can also be subject to sun damage, peeling, warping, and discoloration.

• Fiberglass. Offers high insulating, lower expansion, and contraction.

• Wood clad. A wood frame covered with metal or vinyl offers good insulation and low maintenance, with lower expansion and contraction.

Doors

Of all the parts of a house, doors suffer from a lot of use, especially weather-stripping and thresholds. Although much can be done to extend their life, eventually maintenance and repairs cannot overcome issues such as warping or component deterioration.

What to look for in new doors

Doors, too, offer a wide range of choices for materials, finishes, and insulation. As with windows, the ENERGY STAR® designation and the NFRC label will tell you the energy efficiency of a particular door. U-factor is the most important consideration for doors; a rating of 0.30 or less is recommended. Keep in mind that the more glass area in a door, the lower the thermal performance.

Several features contribute to the ENERGY STAR® and NFRC ratings in doors, including:

• Insulated steel. Commonly made with a steel face and filled with polyurethane insulating foam — with a U-factor as low as 0.17 — these doors can exceed the energy performance of a wood panel door considerably. They usually come prefinished and prehung in a weather-stripped frame.

• Wood. Although the traditional wood panel door has the benefits of less expansion and contraction than steel doors, it also has a relatively poor thermal performance (U-factor of about 0.50) and has higher maintenance requirements.

• Insulated fiberglass. With the thermal advantages of an insulated steel door, fiberglass products usually have a wood-like appearance and are paintable and stainable. In addition, they have less expansion and contraction than steel doors.

Pay attention to the bottoms of doors

The bottoms of doors, unlike jambs, are subject to additional wear and therefore the weather-stripping must be more durable. There are two ways to strip this area: by using a threshold or by attaching a door bottom or sweep. Some thresholds will adjust to accommodate different clearances, but others will not.

Door sweeps require no clearance, because they attach to the side of the door. Thresholds are generally installed to replace existing worn out ones. Often only the vinyl or rubber weather-stripping is defective, not the entire assembly. Check to see if new inserts can be purchased separately. If the whole threshold must be replaced, select one with replaceable gaskets.

Door bottoms or sweeps are usually installed on doors with no existing bottom weather-stripping. They are installed flush with the floor or threshold of the existing sill to provide a positive seal against air movement. Select a sweep that can be adjusted to compensate for wear or movement due to dimensional changes from temperature fluctuations.
There are several systems for providing heat to your home, depending primarily on the way heat is distributed throughout the building.

Furnaces move heated air through ductwork and into rooms via registers. Boilers heat water and send it to room radiators through pipes. Space heaters provide heat to individual rooms. Different fuels provide different advantages and costs.

Furnaces
The most common equipment used for heating homes is a furnace, which heats air and distributes it throughout the home. Furnaces are usually controlled by a single, centrally located thermostat.

Types of furnaces
Furnaces heat air by using electricity or by burning a fuel (usually natural gas, propane, or fuel oil) and then distributing the warmed air to the various rooms in the house.

Forced-air furnaces are the most common type of furnace and blow heated air throughout the house with a fan through a network of ducts and registers. These systems provide the opportunity to control heat levels in individual rooms by operating registers and baffles in the ductwork.

Gravity-fed furnaces blow heat air which is heated in a furnace and then distributed throughout the house by gravity. The furnace filter is located between the return duct and the furnace.

Furnace filters have an arrow that indicates airflow direction; make sure it is aligned with the direction that air is flowing from the return duct into the furnace.

Furnace repairs & maintenance
Modern furnaces—especially high efficiency models—are more complicated than models from decades ago. The efficiency gains are due in large part to the careful balancing of fuel, combustion air, and exhaust gasses. The management of these systems is accomplished through electronic controls, which need periodic adjustment and cleaning for optimum performance. An annual clean and tune of the furnace will keep the systems properly adjusted, and potentially reduce costly future repairs. A qualified technician should:

- Check ignition and flame sensor
- Pull and clean burners
- Inspect heat exchanger for excessive rust or cracks
- Blow out condensate line (90%+ models)
- Check system static pressure
- Do a combustion analysis
- Check gas pressure
- Check for gas or venting leaks
- Inspect and lubricate blower motor

Additionally, there are a few things that homeowners can do to keep their furnace operating efficiently and safely:

- Furnace filter replacement. A clogged furnace filter reduces the airflow through the system, making the furnace work harder and longer to deliver heat throughout the house. A standard filter (about 1 inch thick) should be replaced monthly, especially under dusty conditions. Larger pleated filters (3-6 inches thick) are designed to remove smaller particles (pet dander, pollen, etc.) and may last several months. It is important to check with the furnace manufacturer to determine what types of filters can be used and how frequently they must be changed.

Furnace efficiency savings: an example
Calculators (available online) can help determine potential energy savings between different furnace efficiency standards. The following example was based on a calculator from the Center for Energy and Environment (ncee.org).

Results. These are the annualized numbers from the calculator:

- Efficiency: 80% 95% Savings
- Thermo: 2,396 2,017 379
- Dollars: $1,844 $1,553 $291
- CO2 Lbs.: 26,520 22,340 4,180

In this example, a savings of nearly $300 a year (at present costs) translates into $4,500 over a 15-year estimated life of the furnace—enough to cover the additional cost of the more efficient furnace several times over.

When to replace?
A furnace may be the most expensive piece of equipment in most homes, and deciding when to replace it is a significant decision for homeowners. Having to buy a new furnace in January after the old one has unexpectedly died may not lead to the best choices for you and your home. Instead, start your research in advance, based on:

- Age. As your furnace approaches the end of its expected life, start planning your replacement strategy, including not only what to buy but how to pay for it.

- Expensive repairs. Even if the furnace may have more years of expected life, spending 25% or more of the cost of a new furnace on repairs may be an indication it is time to replace rather than repair.

- Poor energy efficiency. Furnaces that deliver 80% AFUE (annual fuel utilization efficiency) or less are costing you real dollars in fuel use. An increase in efficiency to 95% may easily pay for itself during the life of the new furnace.

The furnace filter is located between the return duct (sometimes called “cold air return”) and the furnace. The air is returning to the furnace from throughout the house, where it is heated and redistributed through the supply duct.

Furnace filters have an arrow that indicates airflow direction; make sure it is aligned with the direction that air is flowing from the return duct into the furnace. Some systems have a filter cover which covers the access to the filter. Be sure that it is sealed tightly to prevent air leaks. If there is no filter cover, seal with metal foil tape.
The dangers of CO
When the by-products of combustion are not properly vented to the outside, it can lead to unhealthy conditions. Among the most dangerous components is carbon monoxide (CO), an odorous, invisible gas that causes illness—sometimes death—among many Mississippians every year.

What to look for
The symptoms of CO poisoning are easily confused with those of a flu or cold: headache, nausea, irritated eyes and nose, and—eventually—confusion and lethargy. The physical symptoms lessen when the furnace was cold. Significant advancements have been made in the past few years in blower motor design and operation, improving efficiency and comfort. Variable speed motors (controlled electronically) automatically adjust the flow of the blower motor to changing conditions and use up to 60% less electricity. They also increase comfort by reducing the rush of cold air at the beginning and end of the cycle.

Another option when reviewing blowers motors is to add electronically commutated motors or ECM motors. These motors are more efficient than a variable speed blower motor and can reduce fan noise considerably.

Sealed combustion
New high efficiency furnaces no longer take room air for combustion or allow exhaust gases to rise naturally up a chimney. A sealed combustion furnace keeps the airflow of combustion completely separated from the interior air of the house. This accomplishes several things essential to the safety and efficiency of the furnace:

- No backdrafting. Fresh air is drawn in through a plastic PVC pipe, delivered to the combustion chamber where the fuel is burned, and the exhaust gases are vented directly to the outside through a similar plastic PVC pipe with the aid of a fan. As the connections in this system are tightly sealed, the dangers of backdrafting as a result of the operation of the furnace are essentially eliminated.
- Increased efficiency. Because the airflow to and from the furnace can be tightly controlled, the ability to provide maximum efficiency in the combustion process is enhanced.

Blower motor
The blower motor operates the fan that distributes heat throughout the home. Older furnaces typically had one speed that would come on as soon as the thermostat called for heat and run until the furnace was cold. Significant advancements have been made in the past few years in blower motor design and operation, improving efficiency and comfort. Variable speed motors (controlled electronically) automatically adjust the flow of the blower motor to changing conditions and use up to 60% less electricity. They also increase comfort by reducing the rush of cold air at the beginning and end of the cycle.

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- Increased efficiency. Because the airflow to and from the furnace can be tightly controlled, the ability to provide maximum efficiency in the combustion process is enhanced.
When shopping for a new boiler:

- **Age.** As your boiler approaches the end of its expected life, start planning your replacement strategy.
- **Expensive repairs.** Even if the boiler may have more years of expected life, spending 25% or more of the cost of a new boiler on repairs may indicate replacement rather than repair.
- **Poor energy efficiency.** Boilers that deliver 70% AFUE (annual fuel utilization efficiency) or less efficiency are costing you real dollars in fuel use. An increase in efficiency may easily pay for itself during the life of the new boiler.

### Efficiency

**Higher efficiency boilers will provide ongoing benefits, including lower energy bills and reduced environmental emissions.** The minimum AFUE rating for a gas-fired hot water boiler is 82% and for an oil-fired hot water boiler is 84%.

Going from a 70% efficient boiler to a 98% efficient one could save significant dollars in fuel costs and the attendant environmental costs of using the fuel. High efficiency gas-fired boilers cannot have a constant burning pilot, and must have an automatic means for adjusting the water temperature to match the heating load.

**Proper sizing** It is important to determine the proper size of a new boiler for a given home. Be wary of being sold a unit that is larger than the previous boiler—oversized boilers cycle more frequently, causing extra wear and actually lowering the comfort level—and will be more expensive to purchase. If significant improvements to the building (additional insulation, air-sealing, new windows) have been made, a smaller boiler might be appropriate. The building code requires a heat-loss calculation based on the size of the house, the insulation levels, the number windows, previous energy bills, etc. Insist on a heat-loss calculation worksheet as part of the new boiler contract.

**Sealed combustion** New high efficiency boilers no longer take room air for combustion or allow exhaust gasses to rise naturally up a chimney. A sealed combustion boiler keeps the airflow of combustion completely separated from the interior air of the house. This accomplishes several things essential to the safety and efficiency of the boiler:

- **No backdrafting.** Fresh air is drawn in through a plastic PVC pipe and delivered to the combustion chamber; the fuel is burned and the exhaust gases are vented directly to the outside through a similar plastic PVC pipe with the aid of a fan. As the connections in this system are tightly sealed, the dangers of backdrafting as a result of the operation of the boiler are essentially eliminated.

- **Increased efficiency.** Because the airflow to and from the boiler can be tightly controlled, the ability to provide maximum efficiency in the combustion process is enhanced.

- **Lower flue gas temperatures.** Because more heat is being extracted from the combustion process (through a secondary condensing heat exchanger), less heat is going out the exhaust. This lowers the flue gas temperature, allowing it to be vented through the PVC piping. This lower temperature also reduces risks associated with hotter flue gasses.

Additionally, high efficiency boilers use electronic ignition (rather than a pilot flame) to initiate combustion. Further electronics manage the air/fuel mixture and ensure efficient and safe operation under a wide range of conditions. When it comes time to replace a boiler it must be matched to the distribution systems:

- **Sealed baseboard systems.** When it comes time to replace a boiler it must be matched to the distribution systems. A sealed combustion boiler, for example, may not operate efficiently with radiators. In some cases, a higher efficiency boiler may also require an upgraded distribution system.

### Electric heating systems

Electric heating is any process in which electrical energy is converted to heat, including resistance and radiant electric systems:

- **Baseboard convectors** are a common way to distribute supplemental heat into areas that don’t receive sufficient heat from the primary system, such as basements. Directly connected into the house’s wiring system, baseboard convectors are inexpensive to install. They are usually controlled with a thermostat on the unit or on a nearby wall.

- **Electric furnaces** use an electric resistance coil located in the ductwork of a forced-air system. Because it can share the fan and ductwork, this type of system is compatible with central air conditioning units. Some models can also accommodate thermal storage devices, to take advantage of off-peak electric savings programs.

- **Electric plenum heaters** are typically used in combination with a gas- or oil-fired forced-air furnace system. They are usually installed to supplement a more costly or less available delivered fuel source, also to take advantage of off-peak electric savings programs. Installed in the furnace plenum or main trunk line of the ductwork, it uses the existing furnace fan to move air through the ducting system. Although a plenum heater and the furnace often use the same thermostat controls, they can also be controlled separately, allowing for independent fuel selections.

- **Radiant electric heating** consists of cables that are typically installed in floors, although they can be used in ceilings or wall panels as well. When installed in a floor, the cables usually heat a thermal mass (such as concrete or tile) which then transfers the heat slowly to the room over time. In-floor systems with thermal mass storage can also take advantage of off-peak electric rates to reduce operating costs. Wall or ceiling panels operate on the thermal principle of radiance, and the cables emit infrared rays that warm bodies more than the air or other things in a room. Electric radiant heating is most easily installed during new construction or major remodeling and is appropriate for energy-saving zoned heating.

How efficient is electric heat? The efficiency of electric heating is 100% because all the purchased energy is converted to heat—there are no heat losses that go up the chimney or out of the vent pipes. (An exception are those electric heaters that are located outside the living space, such as attics or porches. These will lose some heat to the surrounding air, thus reducing their effective efficiency.) However, if the generation and distribution of the electricity is considered, the overall efficiency drops. When compared with other fuels used for home heating, electricity use also contributes more CO2 to the environment per BTU and—depending on current costs—can cost more per BTU.

In locations with limited home heating options, electric heat can be a good choice. Installing zoning and taking advantage of less expensive off-peak usage can make electric heating cost-effective.
Electric heating repairs & maintenance

Because there are few moving parts, most electric systems have a very long expected lifetime. As with combustion furnaces, electric furnaces require similar maintenance regarding filters and other controls. Other potential problems may occur with zoning switches or thermostats, remedied by cleaning and replacement as needed. Occasionally, breaks in lines or circuits can occur, due to floor or wall movement or other construction projects. These may require an electrician to isolate and repair or replace damaged sections. In the case of cable buried in concrete, repair costs may be prohibitive.

Space heating

Space heating refers to equipment that provides heat to a small space, usually a room. This equipment is usually portable but may include fixed installations, such as fireplaces.

- **Unvented combustion space heaters** that use fuels such as kerosene, heating oil, propane, charcoal, white gas, or anything else that burns are extremely dangerous and illegal to use in a confined space! The risks include carbon monoxide poisoning, as well as potential fire hazards. Many of these devices were sold years ago, before there was a complete understanding of the dangers—and before we began to tighten our homes with insulation, air-sealing, and new windows and doors. Even unvented units used in attached garages are unsafe, due to the potential of gasses leaking into the home.

- **Vented combustion space heaters** include units such as gas or wood fireplac-es and gas/oil/wood stoves. Because they are vented to the outside, these devices are not portable and require a fixed location in a room. Some units are designed to be vented out through a special panel inserted into an open window. As with all combustion devices, proper installation, venting, fuel supply,

and spacing from walls and furniture are essential for safe operation. Incorrectly installed and sealed homes, these devices will likely require a fresh air supply to operate properly and safely.

- **Electric space heaters** are the most common type of space heating. Consisting of a floor unit plugged into a wall outlet, these can be of several types, including radiant heaters, oil-filled heaters, and heaters with circulation fans to distribute the air throughout the room. Newer models have automatic shut-off switch-es in the event they are tipped over.

Wood and biomass systems

Before the 20th century, 90% of Americans burned wood to heat their homes. As fossil fuel use rose, the percentage of homes using wood for fuel dropped, falling to less than 1% of all households by 1970. During the energy crises of the 1970s, interest in wood and biomass heating resurfaced as a renewable energy option. That interest has slowly grown (about 2% of Minnesota households now heat with burned wood to heat their homes. As fossil fuel use rose, the percentage of homes using wood for fuel dropped, falling to less than 1% of all households by 1970. During the energy crises of the 1970s, interest in wood and biomass heating resurfaced as a renewable energy option. That interest has slowly grown (about 2% of Minnesota households now heat with burned wood).

- **Ventilated combustion units** are the most com-mon type of space heating. Consisting of a floor unit plugged into a wall outlet, these can be of several types, including radiant heaters, oil-filled heaters, and heaters with circulation fans to distrib-ute the air throughout the room. Newer models have automatic shut-off switch-es in the event they are tipped over.

Wood and biomass systems can be either space heaters (such as fireplaces or stand-alone stoves) or they can provide the fuel for furnaces or boilers for central heating.

Fireplaces

Traditional fireplaces draw as much as 300 cubic feet per minute of heated room air for combustion, and send it straight up the chimney. Although some fireplaces can be fitted with dedicated air supplies, glass doors, and heat recovery systems, wood fireplaces are nearly always net energy losers—especially at the end of a burn cycle when very little heat is being generated. Only high efficiency fireplace inserts increase the heating efficiency of older fireplaces. The inserts function like wood stoves, fitted into the masonry fireplace and using the existing chimney. Proper installation of fireplace inserts is very important to increase efficiency and reduce risks associated with chimney failures.

Wood stoves

Wood burning appliances and fireplac-es can produce large quantities of air pollutants. Wood smoke contains nitrogen oxides, carbon monoxide, organic gases, and particulate matter, each of which has serious health effects, especially to those who have compromised respiratory conditions.

Some cities restrict wood burning appliances when local air quality becomes unhealthy. Others restrict or ban the installation of wood-burning appliances in new construction. Before installing a wood- or pellet-burn-ing system, contact your local building codes department about regulations that may apply in your area.

Pellet fuel appliances

Pellet fuel appliances burn small pellets (less than 1 inch) that are made from compacted sawdust, wood chips, bark, agricultural crop waste, and other organic materials. They have a much higher combustion and heating efficiency than ordinary wood stoves or fireplaces and produce very little air pollution. In fact, pellet stoves are the cleanest of all solid fuel-burning residential heating appliances. They are also exempt from United States Environmental Protection Agency (EPA) smoke-emission testing requirements. Many pellet burners can be direct-vent-ed and do not need an expensive chimney or flue. They are available as freestanding stoves, fireplace inserts, or pellet-fired furnaces and boilers. All pellet fuel appliances have a hopper to store the pellets until they are needed for burning. Most hold enough fuel to last a day or more under normal operating conditions. A feeder device, like a large screw, drops a few pellets at a time into the combustion chamber for burning. Advanced models have a small computer and thermostat to govern the pellet feed rate.

Pellet appliance exterior stays relatively cool while operating and, because they burn fuel so completely, very little creosote builds up in the flue and there is less of a fire hazard.

Maintenance of wood and biomass systems

Newer wood- or pellet-burning sys-tems are efficient if regularly main-tained. Before each heating season have a chimney sweep (certified by the Chimney Safety Institute of America) inspect your wood-burning system. A certified chimney sweep will help make sure your appliance, hearth, connecting pipe, air inlets, chimney, and all other components are functioning efficiently and safely.

Catalytic combustors need to be inspect-ed at least three times every heating season and replaced according to the manufacturer’s recommendations. Most catalytic stoves or inserts have a view window or thermometer to help you check the combustor.
Cleaning out the inside of the appliance with a wire brush periodically will also help your wood-burning appliance heat your home efficiently. Even a one-tenth inch of soot can drop the heat transfer efficiency of the metal by 50%.

Access and storage of biomass fuels
Before purchasing any type of wood or pellet heating system, ensure that you will have long-term access to the fuels and that you have considered the costs of delivery and storage—including protection from weather.

Additionally, determine if your municipality has any restrictions for on-site storage of wood or pellets. Some cities prohibit the transport or storage of wood products that might harbor damaging insects or disease.

Solar heating
There are two basic ways we can use the sun to heat our homes:
• Through passive design that allows sunlight to enter through windows and warm the contents passively;
• Through active roof- or wall-mounted panels that allow the sun to heat a medium (air or water) which is then distributed through the house.

Passive solar design
The components of designing a building to take advantage of the sun have been around as long as there have been structures that people have built. A simple orientation to allow sunlight to enter passively through windows provided not only illumination but additional heat from the sun’s rays.

Today we blend the heat transmitting properties of windows with the heat absorbing capabilities of interior materials and structures, usually as part of new construction or major remodeling projects. A well designed passive approach can supply sufficient solar heat gain to provide a significant portion of the heat load—especially when coupled with high levels of insulation and air-sealing. Often, passive design requires minimal additional costs, especially at early stages of the design process.

Passive solar design includes several elements:
• Large south-facing windows that gather sunlight from the low sun angles that occur during the heating season. These windows often have a somewhat higher solar heat gain coefficient to allow more solar gain in the winter.
• Roof overhangs, awnings, or other devices that provide shading from the higher-angled summer sun, thus reducing cooling loads in warmer seasons.
• Thermal storage capabilities that allow the heat from the sun to be absorbed and emitted slowly during the evening hours. These structures may include masonry walls and floors, although they must be carefully designed and sized to maximize the heat transfer process.

Active solar heating
Active solar heating systems (solar thermal) require collectors, pumps, fans, ducts, or piping to absorb and distribute the heat gathered from the sun. There are two basic types of active solar systems which can provide supplemental heat to a building: liquid- and air-based systems.

Liquid systems use the sun’s energy to heat a liquid (usually an antifreeze/water mix) in a collector that is mounted on the south-facing roof of a building. As the liquid is warmed, it is pumped to an insulated storage unit where an exchanger distributes heat through the system: hot water baseboard, in-floor, radiator, or forced-air furnace.

Air systems use a collector (often mounted on the exterior of a south-facing wall) to collect air heated by the sun. A small, thermostatically controlled fan takes warm air from the collector and sends it through a duct and into the building; a return duct brings cooler air into the panel to be heated. Air systems are usually provided to supplement traditional heat for a room or section of a house, rather than being tied into the main heating distribution system.

Siting and sizing a system
Proper siting will maximize the amount of energy collected. A solar site assessment can determine feasibility and proper locations for solar. A qualified solar installer will properly size and site a solar thermal system and provide ongoing system maintenance.

Heat pumps
Electric heat pumps (which use a compressor similar to a refrigerator) extract heat from a “sink”—usually either the ground or the air. The captured heat is distributed with a heat exchanger through existing distribution systems. In summer, this cycle can be reversed to provide cooling.

Air source heat pumps
Air source heat pumps (ASHP) can extract heat from outdoor air in warmer climates; sub-freezing temperatures reduce the efficiency of most systems, requiring backup heating in our Minnesota climate. Some newer designs can provide heat at lower outside temperatures, but installation and operation costs should be carefully compared with other available fuel sources and systems for heating. Air source heat pumps can also provide a good cooling option, especially in homes without ductwork.

Ground source heat pumps
Ground source heat pumps (GSHP) are used for space heating and cooling; some systems also provide domestic hot water heating.

As with air source heat pumps, GSHP systems rely on a compressor to extract or expel heat with a “sink” — in this case the ground. The part of the system in contact with the ground is called the “loop” and it is most commonly used in two forms: vertical and horizontal loop fields. Larger structures such as commercial buildings and schools often use vertical systems because there is insufficient land available for a horizontal loop system to provide enough heating and cooling for the building.

Horizontal trench installations are more common for residential installations, particularly for new construction or where sufficient land is available. It requires trenches at least 6 to 12 feet deep depending on soil type and climate zone.

When are heat pumps the right choice?
The decision to choose GSHPs for heating and cooling a building can be challenging, as there are many variables to consider when designing an efficient and affordable system. As with all heating and cooling systems, there are circumstances that provide optimal performance for GSHP systems: large building, high cooling load, southern climate, fine soils, available land, and efficiently designed building. As these ideal conditions decrease, the expected performance will also decrease, and installation, operation, and maintenance costs may rise—requiring adjustments in payback calculations.

Are heat pumps renewable?
Heat pumps are powered by electricity and are as renewable as the source of the electricity that powers them. Grid-source electricity in Minnesota is presently over 25% renewable, and increasing. Additionally, any heating or cooling backup systems are also only as renewable as the fuel sources. The carbon load of available fuels should be considered when calculating environmental impacts.

The best way to ensure GSHPs are renewable is to include a solar PV installation to provide the offset electricity required to operate the system.
Reducing heat in your home

There are several things you can do to reduce the amount of heat that enters your home, to reduce the amount of heat you generate inside your home, and to expel the heat that is inside.

Solar heat gain

Although gaining heat from the sun is welcome in the winter, the summer sun adds significant amount of solar heat gain, because the sun is higher in the sky and there are more daylight hours.

Trees.

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Radiant barriers

Do they reduce your energy bills or just reduce your wallet?

Radiant barriers consist of a reflective film, usually aluminum, laid over the top of attic insulation or stapled to the underside of roof rafters in existing homes. They are sold as an energy-saving product, with claims of significant reductions in both heating and cooling costs. However, their potential benefit is primarily in reducing air conditioning loads in warm or hot climates and in buildings with little or no insulation.

Radiant barriers make no sense in Minnesota, as it is not considered to be a hot climate state. In fact, the potential savings on air conditioning in a typical Minnesota home would provide a payback of nearly 100 years!

It is far more effective (and usually cheaper!) to install adequate insulation along with proper air sealing.

Keeping our homes comfortable in the summer months is nearly as important as in the winter. Although Minnesota historically averages about 12 days a year of 90-degree or warmer weather, there have been increasing numbers of hot days and a significant number of days with high heat index numbers. As these extreme weather events continue, the health and safety issues for the elderly, the very young, and ill people make home cooling more important—and an increasing part of home energy costs.

One of the things that make the summer more uncomfortable is that your house can become very warm even when the outside temperatures are not extremely high. This is because the sun is higher in the sky and there are more daylight hours. The sun is more powerful and can penetrate through the roof and walls of your home, warming it up.

Radiant barriers work by reflecting the heat back to the source, the sun. They are made of a reflective material, such as aluminum, and are installed on the underside of roof rafters or on the top of attic insulation. They help to reduce the amount of heat that enters your home from the sun.

However, radiant barriers do not work as well in warm or hot climates. In fact, the potential savings on air conditioning costs are not considered to be a hot climate state.

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**Sizing of ceiling fans**

Proper sizing of a ceiling fan will provide the most efficient cooling for the occupants of a given room. Use these guidelines when purchasing (and don’t forget to look for the ENERGY STAR® label):

<table>
<thead>
<tr>
<th>Room Size</th>
<th>Fan Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 ft²</td>
<td>36”</td>
</tr>
<tr>
<td>150 ft²</td>
<td>42”</td>
</tr>
<tr>
<td>225 ft²</td>
<td>48”</td>
</tr>
<tr>
<td>375 ft²</td>
<td>52”</td>
</tr>
<tr>
<td>400 ft²</td>
<td>2 or more fans</td>
</tr>
</tbody>
</table>

**Whole-house fans**

These are not recommended in our climate. Cutting a large hole in the ceiling to install a whole house fan creates potential air leaks and a source of heat loss in the winter, since it is very hard to seal and insulate around the fan. Whole-house fans may also depressurize your house, leading to dangerous backdrafting of combustion appliances like water heaters.

**Attic fans**

Attic fans move air into and through the space in your attic above the insulation. Using an attic fan to cool your house has limited value. A properly sealed and insulated attic will have limited value.

**Air conditioning**

Air conditioning operates on the same principles as a refrigerator: a refrigerant is compressed from a gas to a liquid and when it changes back to a gas, energy (in the form of heat) is absorbed. That captured heat is expelled to the outside, lowering the temperature inside the house. Additionally, as air is cooled it is less able to hold moisture, so the air inside the house becomes drier—which is more comfortable for the occupants.

All air conditioners consist of a condenser unit, which sits outside the house and serves to condense the circulating refrigerant, thus releasing the captured heat to the outside. The now-cold refrigerant is pumped to the evaporator, which is located inside. As the fan blows air over the evaporator it transfers its heat to the refrigerant. The air that is distributed is now much cooler, and the warmed refrigerant is pumped back outside to the condenser to start the cycle again.

**Ducting or forced-air systems**

The most common type of distribution system uses the same metal ducts and a fan that move heat created by a furnace—the forced-air system. The ducts can also serve as pathways for cool air; this system is commonly known as central air conditioning. Usually controlled by the same thermostat that operates the furnace, central air offers the convenience of cooling the entire house, while allowing for adjustments (through baffles and registers) in individual rooms.

**Ductless systems**

Ductless systems work well for homes that use hot water or steam for their heating systems, and thus do not have traditional ductwork. Small tubes run between the outdoor condenser and the indoor wall-mounted unit, forming a closed-loop system. The cooling component is mounted on the walls of one or more rooms and resembles a room air conditioner, but it is much quieter. The condenser is installed outdoors, similar to a central air conditioner. Some ductless systems will support multiple terminals and may have a cooling capacity equal to traditional central air systems. Another advantage of the ductless system is the ability to cool only selected rooms.

**High velocity systems**

Another option for homes without traditional ductwork is the high velocity system, which uses smaller ductwork that can be placed within existing wall cavities. Main trunks may be only six inches in diameter, with delivery ducts only three inches in diameter. Along with the outdoor condenser unit, the systems include an air handler with a higher velocity fan that blows air over the evaporator unit and then through the smallerducts. Although sometimes challenging to install, a high velocity system can deliver cool air throughout the home and allows for individual room controls through registers.

**Window/air units**

Most common in rental units and older homes, window/ wall air conditioners can provide cooling to a limited area in a home—usually one or two rooms at most. A window air conditioner combines the condenser and evaporator elements into one unit that sits within an open window frame. A wall unit is similar except that it sits in a separate opening in the wall. The condenser portion is on the outside and expels the heat, while the room air is circulated over the evaporator on the inside, providing cooling into the room. Proper installation of window units will prevent air leakage around the unit (through insulated “filler” panels and other tight-fitting gaskets) and will provide a way to secure the window to prevent opening from the outside.

Additionally, it is important to make sure the electrical requirements of the unit are not more than the circuit it is using.

**Air conditioner repairs and maintenance**

A central air system uses the same ductwork, fan, and controls as the forced-air furnace, so some of the maintenance requirements are the same. A qualified service technician should also:

- **Inside unit**
  - Inspect and clean evaporator coil, drain pan, and condensate drain lines
  - Inspect control box, wiring, and connections for wear or damage
  - Ensure insulation on tubing is intact

**Where does the moisture go?**

A significant effect of air conditioning is the removal of moisture—a result of cooling the air. But where does it go?

In a central air system, the moisture is collected in the evaporator within the furnace ductwork. This water, or “condensate,” is carried away by a hose to a nearby drain. It is very important this hose remain open and connected to the drain. Condensate backup (due to clogs, pinches, or bends in the hose) will spill onto the floor, adding moisture back into the home and allowing for individual room controls through registers.

**Saving electricity with a central air conditioner**

Some electric utilities offer billing options that include lower rates for off-peak use of air conditioners, often during evening hours.

Additionally, many will provide a discounted rate when a homeowner agrees to allow the utility to remotely control the operation of the condenser portion of the unit during periods of high electricity demand.

Usually the interruptions are not noticed by customers (circuiting fans remain operational, and the “down” times are usually short). The benefit to the utility is better management of electric demand, which means the ability to avoid relying on expensive generation during peak usage events.
Other alternatives. Air source heat pump units can also provide cooling, but careful design and proper sizing are key.

A solar absorption chiller can provide the energy needed to cool your home. In a gas absorption chiller, like a gas refrig-

erant, the evaporator coil is the heat source, the condenser the heat sink. The cycle starts when the refrigerant enters the condenser, gets heated, and changes phase from gas to liquid. It then flows through the expansion device, where its pressure is reduced, and then into the evaporator coil, where it absorbs heat from the space to be cooled. The cycle is repeated.

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Refrigeration systems work by removing heat from the space to be cooled and rejecting it to the outside. This is done by converting a refrigerant from a gas to a liquid, which requires a reduction in temperature.

Central air conditioners have an expected life of about 15-20 years and can show signs of their age through refrigerant leaks, motor failures, and an inability to efficiently cool the house. Installing a new unit before the old one fails completely allows for time to care-

ful shopping, as well as enjoying the energy savings of a high efficiency unit.

Proper sizing

Over-sizing an air conditioner is the most common mistake made by consumers, thinking that "bigger is better." Buying too large a unit is not only expensive, it can increase discomfort by not removing enough humidity from the air, leaving you feeling cold and clammy. The primary tasks of an air conditioner are to cool and dehumidify, but a typical unit is much more efficient at cooling. Since the major control in an air conditioner is a thermostat, and not a humidistat, the unit comes on and shuts off in response to air temperature, regardless of humidity. A system that is too large often achieves the desired temperature before the humidity is adequately removed.

If a system is too small, it may dehu-

midify well but not cool the air suffi-

ciently. A properly sized unit needs an operating cycle long enough to balance the removal of both heat and humidity. Factors such as the amount of shade around your house, window area, and the insulation and tightness of the building envelope will also help deter-

mine the correct size of an air condition-

er for your home.

Make sure that your contractor does a heat-gain calculation to ensure the proper sizing of the equipment.

Efficiency ratings

Because air conditioners operate on electricity, more efficient models will not only save money, they will also reduce environmental effects related to electricity generation. Since 2006, all residential central air conditioners sold in the United States must have a seasonal energy efficiency ratio (SEER) rating of at least 13. The higher the SEER rating number, the more efficient it is for cooling. ENERGY-STAR® qualified units must have a SEER rating of at least 15, and there are units available with SEER ratings of 23 and higher.

Room air conditioners are also re-

quired to carry an "Energy Guide" label showing their energy efficiency ratio (EER). A higher EER rating means higher efficiency. Purchase an ENERGY-STAR® model with an EER of 12 or higher.

Ultimately, purchasing the most efficient air conditioner will provide energy-savings payback over the life of the equipment.

Dehumidifiers

Considerable cooling effects can be achieved with the use of a dehumidi-

fier in certain situations. Often found in basements (because of the cooler temperatures and higher humidity levels), dehumidifiers have a bucket or pan that can be periodically emptied. Most have an automatic shut-off when the container is full. Many units also allow for the attachment of a hose that can be run to a floor drain. One downside of a dehumidifier is that it pumps out heat as a result of the de-

humidification process. Generally this is minimal, and the dryer air offsets the additional heat gain.

Relative humidity and humidistats

Relative humidity (RH) is the amount of water vapor actually present in the air compared to the greatest amount of water vapor the air can hold at that temperature. The optimum RH level for a building is generally considered to be between 30% and 50%. Anything above this range may promote bacte-

ria growth. (In Minnesota’s climate, during the heating season, humidity levels should be in the range of 30% to 40% RH to prevent window condensation.)

Many dehumidifiers include a built-in humidistat, a device that allows you to set the desired RH level that you would like for the room. Once the room reaches the desired RH level, the dehumidifier will cycle on and off automatically to maintain the level.

Efficiency: energy factor

The energy efficiency of dehumidi-

fiers is measured by the energy factor (EF). In general, a higher energy factor means a more efficient dehumidifier. ENERGY-STAR® models have an EF of at least 2.0 for units that remove less than 75 pints/day and 2.8 for units that remove from 75-185 pints/day.

Why is humidity bad?

High humidity in a home will cause the occupants to feel much warmer, due to simple laws of physics. The higher the humidity in the air, the harder it is for sweat on our bodies to evaporate, which is how we cool ourselves in warm conditions. Even a cooler environment, with high humid-

ity, will feel clammy and uncomfort-

able—think of a cool, damp basement.

Additionally, high humidity coupled with warm temperatures contributes to the growth of mold and mildew, espe-

cially on cooler surfaces such as tile or foundation walls.

Controlling humidity through pro-

per sizing and use of air conditioning equipment, along with use of dehu-

midifiers, can reduce the impact of hu-

midity on occupants and their homes.
Many people are interested in generating electricity on-site to power their home, some because they are off the electrical grid and others because they want to reduce their personal carbon footprint. Although there are several technologies that could be considered, for most residential settings solar photovoltaics (PV) is the most widely used option.

**Why consider solar PV?**

Generating electricity from sunlight has been done for decades, and over the past few years the technology and market has matured to the point of widespread use. Improved efficiency, lower costs, and incentives have made residential rooftop solar a good choice for many Minnesotans.

**Goals of home solar PV installations**

Supplemental. Most solar PV installations are designed to provide a portion of the home’s electrical use and are tied into the electrical grid system. When the panels are producing electricity, the power is used to operate anything in the home that is drawing current. Excess solar electricity is sent into the utility’s electric grid, and a meter measures the amount so the homeowner can be reimbursed by the utility for the excess electricity generated. Because the system is tied into the grid, special permits, approvals, and equipment are required by the utility to ensure safe operation.

**Offset.** Installing a solar PV system to specifically offset electric use by selected equipment (such as electric vehicle charging or powering a heat pump) is one way to add electric load and avoid increasing carbon emissions. These systems can be roof, ground, or pole-mounted and on- or off-grid. If designed to offset specific equipment, the system can be sized to meet just those electrical needs. Larger systems can send excess electricity to the grid or to battery storage.

**Off-grid.** Cabins or other remote locations that are not on the grid can use solar PV to provide all of a home’s electricity needs. Because of the intermittency of sunlight (night and clouds), most off-grid systems include some form of storage, usually in the form of batteries. Additionally, electrical usage is usually reduced considerably through high efficiency products (LED lighting, for example) and choosing non-electric options for devices such as water heaters.

**What to do before you install solar**

Before investing in solar, first consider making some basic home improvements that will save energy:

- **Get an energy audit**
- **Seal air leaks and add insulation**
- **Repair or replace old appliances**
- **Replace old lighting with high-efficiency LEDs**
- **Use a programmable or smart thermostat**

By making your home energy efficient first, you reduce your energy consumption—which will reduce the size of investment needed for your solar energy system and maximize the returns on your system.

**The importance of proper siting**

Before you invest in solar, you need to determine the suitability of your site. A good first step is to enter the property address into the Minnesota Solar Suitability Application (m.gov/solarapp). Clicking on various locations, including roof surfaces, can provide basic information about the solar potential. A more detailed analysis of the site—including future shading concerns from trees or potential issues with the structure planned for mounting—can be provided by a qualified solar professional.

**What to expect from a reputable solar installer**

**Qualifications:** A licensed Minnesota electrical contractor in good standing with the Minnesota Department of Labor and Industry (dll.nng.gov); proof of insurance; certification by the North American Board of Certified Energy Practitioners (nabcep.org); and customer and business references on request. To find installers, check out the Clean Energy Project Builder (cleaneenergyresourceteams.org).

**Site Assessment:** A detailed assessment of your site, including a shading analysis and examination of roofs and other structures to determine feasibility of a solar installation.

**System Sizing:** Calculations that show the number of panels needed to meet a specific percentage of current usage and estimated annual production of the system.

**Permits and agreements:** All necessary building permits, interconnection agreements, and documentation for incentives and manufacturer/installer warranties.

**Manufacturer and installation warranties:** Most solar panels and collectors will have a warranty that guarantees a minimum of 80% output of the name plate capacity for 25 years. The warranty for workmanship by the installer is usually two to five years.

**Costs:** A detailed bid contract that describes all the work to be done and who is doing it (including any subcontractors), all the equipment and materials to be installed, timelines for completion, payment specifics, and process for any change orders. (See page 67 for further information about contracts.)

**Rebates and Incentives:** Documentation for all applicable rebates and incentives and ensuring timely filing.

**Inspections:** Arranging for all required inspections of the project.

**Other Solar Options**

Many people are unable to install a solar energy system on their home or business (because of siting issues, financial hurdles, or because they are renters) but still want to do what they can to support clean energy. Among the options:

- **Green Pricing Programs:** Green pricing is a voluntary option offered by some Minnesota electric utilities that allows you to support renewable energy beyond what your utility would otherwise be required to do. You usually pay a little more for your energy to cover the incremental cost of the additional wind or solar energy. Check with your utility to see if it offers green pricing.

- **Community Solar Gardens:** An emerging option for the customers of several Minnesota electric utilities is joining a community solar garden. These solar photovoltaic systems provide electricity to participating subscribers and are a way for people to get some portion of their power from solar electric systems without installing their own project. The Clean Energy Resource Teams offers information on community solar gardens (cleaneenergyresourceteams.org).

**Rebates and Incentives**

There are several ways for Minnesotans to get financial assistance for installing solar PV at their home or business:

- **Federal Tax Credit:** The U.S. Congress recently extended the personal income tax credit for qualified solar installations through 2021. It will decrease to 26% (from 30%) for systems installed in 2020 and 22% for systems installed in 2021.

- **Utility Rebates & Incentives:** Some Minnesota utilities offer rebates or other incentives for customers installing qualified solar energy systems. Check directly with your utility to see what they offer. For instance, Xcel Energy offers a Solar*Rebates Program for residential and commercial customers who install solar PV systems. It provides rebates with 10 years of annual incentive payments based on the solar system’s annual production. Two other investor-owned utilities—Minnesota Power and Otter Tail Power—also offer solar incentives. Minnesota Power provides solar incentives to qualified customers through its SolarSense program, and Otter Tail Power offers a Publicly Owned Property Solar program that provides cash incentives to public facilities that install solar PV systems.

- **Loan Programs:** Several organizations, including the Minnesota Housing Finance Agency, offer consumer loans for the installation of solar systems.

To learn more about available rebates, incentives, tax credits, and loan programs, visit the Database of State Incentives for Renewables and Efficiency (dsireusa.org).
Good indoor air quality is important for a healthy home. Proper and efficient ventilation removes unhealthy contaminants (such as smoke from cooking, moisture from bathing, or combustion products from heating systems) and brings fresh air into the living spaces.

Types of ventilation systems

There are two basic types of ventilation systems in homes: “point source” and “balanced.”

Point source ventilation

Point source ventilation is located near the source of the contaminated air, such as in a kitchen, bathroom, or workshop. These are usually exhaust only systems — pulling air from inside the house with a fan and exhausting it to the outside through ducts — and are usually controlled by separate, manual switches.

The need for ‘make-up’ air

When exhaust fans operate they pull air from the house — air which needs to be replaced, somehow. In the past, this was done with air that leaked into the building around windows, doors, or foundation cracks. In a well-sealed home, however, there are very few of these leaks. Without an additional source, the fans pull air down chimneys, flues, or other exhaust fans, leading to the entry of dangerous combustion products or other contaminants. The solution is to provide sufficient air to “make-up” the air that is being exhausted. This is usually done with an insulated duct that enters the house (often in the basement). When properly installed, this duct will only allow the entry of air when needed.

Bathroom fans

Building code requires that bathrooms have either an operable window or a fan to remove odor and excess moisture. A bathroom fan is often quicker and more effective than opening a window — especially during heating or cooling seasons. In order to minimize moisture build-up and mold, it is essential that bathroom fans be installed properly, using short, insulated ducts with no bends or kinks. Additionally, fans must be air sealed at the ceiling and insulated to prevent heat loss into the attic, and ducts must be sealed at all joints and connections, all the way through to the exit point at the roof or wall.

ENERGY STAR® rated fans are not only much more efficient, they also are quieter and have a longer estimated life.

Kitchen fans

Most kitchens have hood fans over the stove top or range. Unfortunately, many are not connected to ducts that lead to the exterior, and are merely “recirculating” the air through the fan filter. Although this may collect some of the larger particles of grease, these installations will do little to control smoke, odor, or the by-products of combustion (from a gas stove or range). The same requirements for proper installation apply to kitchen fans as to bathroom fans, and ENERGY STAR® products will perform better than standard ones.

High volume fans require extra precautions

Found in some kitchens, workshops or utility areas, exhaust fans of over 250 cfm (cubic feet per minute) can do a very good job of removing smoke, dust, and other contaminants very quickly. However, their very power can lead to problems with inadequate air supply and they usually require additional make-up air.

Exhaust fan use

Exhaust fans should be used whenever there are indoor air pollutants (including moisture from cooking or showers) that are present in the home. Exhaust fans should be run whenever the pollutants are being introduced into the air and for at least 15 minutes after the pollutants have stopped occurring in the home or until signs that the pollutants have left the home (for example, when there is no longer any condensation on the windows after a shower). The use of a timer switch to control exhaust fans is a good way to provide adequate ventilation and limit run time.

Balanced ventilation: air exchangers

Air exchangers do exactly what their name implies: they exchange stale indoor air with fresh air from the outside. Although the energy savings derived from using an air exchanger is often minimal, the benefits to occupants are significant. As buildings have become tighter, less air moves through leaks around windows, doors, chimneys, etc. This can lead to an unhealthy build-up of odors, carbon dioxide, or volatile organic compounds (VOC). Opening a window may allow fresh air in, but at a considerable energy loss. Air exchangers provide the fresh air needed for occupants and minimize the energy losses for heating or cooling.

- Heat recovery ventilation (HRV) is a system that exhausts air from inside of a home and replaces it with outdoor air.

During this process the system captures heat from the air being exhausted and uses it to preheat the air entering the home. The air flows (fresh and exhaust) don’t mix.
- Energy recovery ventilation (ERV) is a system that does everything that an HRV does with the addition of transferring moisture from the exhausted air into the air entering the home (in the winter) and restricting moisture from incoming air (in the summer). This can provide higher comfort for occupants by balancing the humidity levels inside the home.

Maintenance of ventilation systems

All ventilation systems require periodic maintenance to ensure safe and efficient operation.

- HRV and ERV units should have filters cleaned or replaced in the spring and the fall. Vent openings on the exterior of the home should also be checked for blockages from snow, debris, or insects.
- Exhaust fans should have the fan cleaned once a year, and the dampers on the venting should be inspected once a year to ensure that they are working properly. Kitchen exhaust fans should have the metal filters in the hood washed every few months or when grease builds up.

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Maintenance of ventilation systems

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Water heating is often the second largest energy expense in the Minnesota home and may account for up to 20% of annual household energy costs.

**Water heater options**

Water heaters heat water by using electricity or by burning a fuel (natural gas and propane are the most common). In most cases heated water is stored in a tank and is ready for use when needed. Some only heat water whenever it is called for by the user; these are known as on-demand or tankless water heaters.

**Gas-fired water heaters** Gas water heaters are the most common type in use in Minnesota. Typical gas models have a burner under the tank, and an exhaust stack/heat exchanger that runs through the middle of the tank. The exhaust stack has two functions: it is a vent for the burner and it transfers heat to the water.

- **Atmospherically vented water heaters** use room air for combustion and direct the exhaust gases through a double-wall (class B) chimney through the roof of the house. These units are commonly found in older homes and are the least efficient option. They also carry a risk of backdrafting in certain conditions.

- **Power-vented water heaters** are similar to atmospheric models in that they rely on room air for combustion, but they feature an exhaust system that is assisted by a fan. This reduces the risks of backdrafting. Because of their higher efficiency most models can be vented through a sidewalk or vertical roof vent using PVC piping.

- **Sealed combustion or condensing water heaters** use only outside air for combustion. Again, because they are more efficient at extracting heat from the combustion process, most of these water heaters can be vented with PVC piping.

**Electric water heaters** Most electric models use resistance coils inside the tank. Electric water heaters typically have slower recovery rates than many gas models. They make up for that with larger tanks. Electric water heaters may be more expensive to operate than gas models (depending on rates), but they do have some advantages. Electric units have no chimney or flue pipe, so you can put one almost anywhere in your home— for instance, in a closet or under a sink. The entire tank is surrounded with insulation, so less heat is lost when compared to a standard gas model.

Some local electric utilities offer incentives for installing storage heaters for off-peak applications or control devices that shut off the water heaters for interruptible service.

- **Off-peak electric options.** Storage heating is an inexpensive and efficient method of electric water heating. Many utilities offer low-cost off-peak night electrical rates for water heating. Water is heated at night, storing all you need for daily use. Make sure you have adequate storage capacity and check with your utility company for details.

- **Interruptible electric water heating** allows the utility to temporarily interrupt electricity to the water heater during times of peak electrical usage, usually for a few hours only on the hottest or coldest days of the year.

**Mobile home water heaters** It is very important to install the correct type of gas water heater in a mobile home (or manufactured housing). If your mobile home has an exterior access door, you may use a standard mobile home water heater with an open draft hood (atmospheric vent). If your water heater access door opens to the interior or your water heater is located in a cabinet or closet, you must install a direct-vent mobile home water heater. A direct-vent water heater is designed to prevent the accidental spillage of flue gases into the home. The letters “DV” will appear in the model number.

**Space heat and water heater combination units** Almost all high efficiency boilers can be made to heat potable water. This may be done with an indirect fired water heater, also known as a sidearm water heater. This type of water heater provides a separate zone of heat flow from the boiler to an insulated tank. The hot water flows through a water-to-water heat exchanger which in turn heats the water in the tank. Some boilers may also have a coil inserted into the boiler itself, but this is not as good an idea, being less efficient than the sidearm. When considering such a unit, make sure that the boiler is not too large for your home heating needs and that the water heater is reasonably priced.

**Tankless or on-demand** Tankless or on-demand water heaters have no storage tank; they heat water only as it is needed. These units can be the whole house type (installed in a basement or mechanical room) or can be individual units located near demand points, such as under kitchen sinks. Fueled by either gas or electricity, on-demand water heaters require a large amount of energy over a very short period of time. Because of this, it is important to ensure that electric circuits or gas lines are sufficient to handle the increased demand.

**Heat pump water heaters** Heat pump water heaters (HPWH) take heat from the surrounding air inside the house, or air that is ducted to the unit, and transfer it to the water in the tank. Benefits include dehumidification, a reduced cooling load in the summer, and significant energy savings (when compared with a standard electric resistance water heater). In fact, new federal standards require new electric storage water heaters greater than 55 gal. to use heat pump technology.

There are two types of HPWHs: integral and remote. The integral unit is a heat pump with its own water tank. The remote unit is a heat pump that can be connected to an existing electric resistance water heater tank. The remote unit is less expensive than an integral system. Both types have a resistance element as a backup, either built into the integral unit or left over in the old system to which the remote unit was added.

Ground source heat pumps (GSHP) can also provide water heating in homes with an adequately sized ground source heat pump heating system. There are two water heating options available, and both are generally installed to preheat water in an existing tank type water heater.

- **Desuperheater water heaters attach** to the heat pump and make use of the compressor’s waste heat. A desuperheater water heater can satisfy 60% of domestic hot water requirements during the cooling season and 80% during the heating season. While it provides economical heat during the air conditioning and heating seasons, it does not contribute to heating water during spring and fall periods when the compressor is not operating.

- **Water source HPWHs** are another way to take advantage of a GSHP heating system. A small water source heat pump is tied into the ground source loop to preheat water. The water will be preheated year-round, without the need for the space heating compressor to be operating. Note that with this system the ground loop will need to be sized larger to serve both the space heating and water heating needs.

**Solar water heating** Solar water heaters can reduce the annual fuel cost of supplying hot water to your home by more than half. Throughout the year, the solar water heater system preheats the water before it reaches the conventional water heater. During the summer, the system may provide all of the required heat.

*When replacing a water heater, many people have questions about the differences between tank and tankless systems. In terms of energy efficiency, there is no difference between units that have the same energy factor (EF); it takes the same amount of BTUs to heat water to a given temperature. Where the real difference is lies in what is known as “stand-by” loss, or the amount of heat that escapes through the walls of a tank system when there is no demand for hot water. In an older or less insulated tank, this loss can be significant; newer high efficiency models are very well insulated, and standby losses are greatly reduced. Another concern is estimated water usage for a household. Larger families with higher demand may find that some tankless units are unable to deliver sufficient hot water for simultaneous uses. Select models based on your hot water needs. Finally, when comparing purchase and installation costs, consider upgrades to gas or electric service that may be needed for the high momentary demands of a tankless system.*
Water heating systems include:
- Gas storage tank
- Electric storage tank
- Solar collectors

Efficiency in a new water heater
When looking at a new water heater, compare the energy efficiency of different models by checking the Energy Guide label.

Efficiency tips for water use
- Pipe insulation. Water pipes extending vertically from the hot water storage tank are actually part of the tank itself. The lighter hot water flows up the pipe, replacing cooler and heavier water. Insulate both pipes with foam or fiberglass. This prevents heat loss and improves overall efficiency.
- Your dishwasher is the biggest user of water. It is estimated that a dishwasher uses 4-7 gallons per minute, which means it can save you 1-7 gallons per minute; and most of the water is hot. If your water heater is set at 120 degrees, you can easily pay for the new showerhead in about a year of energy savings.

Water heater repairs and maintenance
A solar water heater typically includes:
- Collectors mounted on the roof or in a clear area of the yard.
- A separate storage tank near the conventional heater in the home.
- Connecting piping.
- A controller.

There are many types of solar water heaters, but only two are appropriate for the Minnesota climate—the closed-loop heat exchanger and drainback systems. Both of these types have protection against winter freezing.

Biofuels
Wood and other wood products (chips, pellets, etc.) can be used to heat water. One approach is to use a tempering tank in the same room as the wood furnace or stove, which then preheats the water in the tank before entering a standard water heater. Another option is a wood-fired boiler that can provide domestic hot water needs along with space heating.

Water heater repairs and maintenance
Water heaters require maintenance in order to operate efficiently and safely. Often a part of annual furnace inspections, a technician should check the following to keep a water heater running properly:
- Check the temperature at a nearby faucet. A maximum of 120 degrees is recommended.
- Check for leaks around the pressure valve and discharge pipe.
- Ensure nothing is stored on or near the water heater—especially anything combustible.
- Electric: inspect the anode rod every three to four years.
- Gas: atmospheric test the draft of the heater with all exhaust fans (including the dryer) and the air handler running.
- Gas: check the fuel input and flame characteristics and adjust the fuel pressure if necessary to achieve the optimum efficiency and an acceptable CO reading in the flue.
- Gas: ensure that the fresh air supply (atmospheric and power vent) is open and that there are no obstructions at the air intake for the burner.
- Inspect all gas, electrical, and venting lines to ensure there are no leaks, breaks, or loose connections.

Energy-saving tips for water use
- Using cold water to flush away food in garbage disposal.
- Wash only full loads of laundry or adjust the water level for smaller loads. Use cold water whenever possible.
- Reduce the amount of water used for tasks that require flowing water without doing similar tasks.

When to replace
Water heaters have an average life expectancy of 10-12 years, but they can last much longer. Most, however, are not replaced until the tank fails and begins leaking—potentially damaging furnishings or structure. Additionally, an old water heater can operate for years at very poor efficiencies before it finally fails. It is often cheaper (and more convenient) to remove an operating but inefficient unit and replace it with a new high efficiency model.

Ask yourself the following questions:
- Does the water heater make popping or cracking noises? This indicates a buildup of sediment in the tank.
- Have you been forced to turn up the thermostat over time to maintain an adequate supply of hot water?
- Do you have very hard water?
- Look under the burner. Is there a buildup of rust or other deposits?
- Is there evidence of soot or burn marks near the vent hood at the top of the tank? This may indicate dangerous backdrafting.
- Using less hot water. Avoiding waste in using hot water is an effective and low cost way to reduce energy costs.
- Try adjusting the water heater heat setting to spread out demand and buy a smaller heater. To estimate your peak hour demand, check out an online calculator, such as what can be found at energy.gov.

The first-hour rating (FHR) is more important than the actual size of the tank because it is an estimate of how much hot water the unit will deliver in an hour. The FHR is displayed on the Energy Guide label. Look for a new water heater with an FHR that is close to the estimate of your household’s peak hour demand. If you only reach your peak once a week and the time of the rest of the time, consider adjusting your use to spread out demand and buy a smaller heater. To estimate your peak hour demand, check out an online calculator, such as what can be found at energy.gov.

Installation
- Installing a water-saving showerhead. A typical showerhead uses between 4-9 gallons of water a minute. A water-saving showerhead uses between 2.5 gallons per minute, which means it can save you 1-7 gallons per minute; and most of the water is hot. If your water heater is set at 120 degrees, you can easily pay for the new showerhead in about a year of energy savings.
- Wash only full loads of laundry or adjust the water level for smaller loads. Use cold water whenever possible.
- Wash only full loads with the dishwasher.
- Wash cold water to flush away food in your garbage disposal.
- Place your water heater on its lowest setting if you are going to be gone for a few days or more.
- Don’t let the hot water run when you are shaving, washing dishes by hand, or doing similar tasks.

Troubleshooting
- Fix leaky faucets. A hot water faucet leaking one drop per second will waste about 60 gallons of hot water a week. This could cost you up to $55 or more a year. Leaks can often be fixed by replacing the tap washer.

What is an orphaned water heater?
In the past, atmospherically vented water heaters and furnaces usually shared the same masonry chimney. When both were operating, the warm exhaust was sufficient to create a draft, pulling the exhaust gasses all the way out of the chimney. When coupled with the leakiness of unimproved homes, the dangers of backdrafting were greatly reduced.

However, when a new high efficiency furnace is installed, the masonry chimney is no longer used to remove the flue gases; that is now vented through a plastic pipe through the wall. This leaves the old water heater orphaned, and unable to generate sufficient draft under some conditions. Together with the tightness of many homes today, that increases the potential for dangerous backdrafting of the water heater.

The solutions are:
- Check the FHR of any issues
- Inspect all gas, electrical, and venting lines to ensure there are no leaks, breaks, or loose connections.
Installation
Most programmable and smart thermostats are not complicated to install. Manuals and online videos can assist homeowners through the process, and usually the only tools required are screwdrivers.

Sometimes, however, programmable or smart thermostats may require wiring that is different from manual thermostat wiring. Especially if you plan to control additional devices, the wires may not be in place to do so. If you need additional wiring for a new thermostat, contact an HVAC contractor or an electrician to run the wires.

Proper thermostat location
The location of your thermostat can affect its performance and efficiency. To operate properly, a thermostat must be on an interior wall away from direct sunlight, drafts, doorways, skylights, and windows. It should be located where natural room air currents—warm air rising, cool air sinking—occur. Furniture will block natural air movement, so do not place pieces in front of or below your thermostat. Also make sure your thermostat is conveniently located for programming.

Programming your thermostat
When programming your thermostat or providing initial settings for your smart thermostat, consider the schedules of everyone in the household, including work/school schedules and sleep times. Consistent times when no one is home or when people are sleeping are good opportunities to lower the settings in the winter and raise it in the summer.

In order to save the most energy, start with settings that are lower in winter and higher in summer than what you are used to (66°-68° in winter and 74°-76° in summer). After a few days, evaluate your comfort, and adjust either the temperatures or the times when the temperatures change. Eventually, you should be able to balance comfort with maximum energy savings.

Why upgrade your thermostat?
Many people are reluctant to invest in newer thermostats, primarily because of concerns about initial purchase costs. The cost of a programmable thermostat is between $20-$150, depending on features; a smart model may be more.

But—if used properly—these models can actually save enough energy to offset their cost, sometimes in a year or so. But the key to their success is proper installation and use. A programmable thermostat that is not programmed (which some research shows may be up to 70% of households) will save no more energy than a manual thermostat.

In those situations, a smart thermostat may actually save more energy, as it requires less attention to operate efficiently.
Appliances are the most common labor-saving devices in our homes. Whether helping us keep clean, comfortable, or nourished, appliances are an essential part of daily life. And although they can save us a lot of time and effort, their use comes with an energy cost.

Refrigerators and freezers

Refrigerators use a lot of energy in a typical home. In fact, in most Minnesota homes a refrigerator is the second largest user of electricity, after air conditioners.

Maintenance & repairs

If you are not ready to replace your refrigerator or freezer, there are a few things you can do to keep your existing equipment operating as efficiently as possible.

- **Cleaning and clearance.** Although the benefits of keeping the coils on the back or bottom dust-free may be minimal, large accumulations or blockages can interfere with efficient operation. Additionally, there must be clearance between the appliance, walls, and cabinets so that air can circulate freely, allowing the coils to give off heat. Spilled food or liquids may also hinder and keep doors and drawers from closing or sealing tightly.
- **Gaskets and seals.** Over time, the gaskets that seal the doors can become worn or loose and may no longer do a good job of keeping the cold inside. If the unit itself is still operating well and is not too old, these can be replaced or tightened.

**When is it time to replace?**

Many refrigerators and freezers will continue to operate for 15-20 years or even longer. However, when the light comes on when the door opens. Whether or not these appliances are really working efficiently, however, is another question. Opportunities for replacement include:

- **Costly repairs.** If an estimate for repairs exceeds several hundred dollars, it might make sense to look at replacement instead—depending on the age and condition of the rest of the appliance.
- **Remodeling project.** A kitchen remodel often includes an upgrade of appliances, in order to accommodate a different space or additional features.
- **High energy usage.** Depending on the model, a 20-year-old refrigerator could use 1,700 kWh of electricity every year—compared with about 450 kWh for a similarly sized new ENERGY STAR® model. An electrical cost of $11 per kWh, that represents a potential savings of $140 per year—and a potential payback of 7-9 years.

**What has changed?**

Refrigerators and freezers have benefited from recent advances in manufacturing methods and efficient technology, including:

- **Better insulation.** The metal boxes that enclose refrigerators and freezers have higher quality insulating materials than in the past, and reduced thermal bridges (the direct, uninsulated connections between inside and outside).
- **Tighter seals.** The gaskets and seals around doors are designed to fit better and have increased durability. Additionally, they are generally easier to replace when worn.
- **More efficient.** The compressors, motors, heat exchangers, and other components are considerably more efficient than previously.

**Shopping tips**

When choosing a new refrigerator or freezer, consider:

- **Proper sizing.** Appliances that are too large waste energy and space. Ones that are too small require more frequent trips to the grocery store. A typical family of four requires a refrigerator capacity of 12-16 cubic feet and another 6-8 cubic feet for freezer capacity.
- **Styles.** The most efficient refrigerator designs usually have the freezer compartment on the bottom. The least efficient are usually the side-by-side models. Chest freezers are generally more efficient than vertical models (less cold air spills out of a chest freezer). Other factors such as compartment dimensions or easy access may be important as well.
- **Features.** Manual defrost typically uses less energy than auto-defrost models, but they may be difficult to find in all sizes—and they must be defrosted manually to properly operate. Although “through-the-door” water and ice dispensers can reduce frequent door opening, they can also add to the energy consumption.

**Efficiency.** As major users of electricity, the selection of refrigerators and freezers will affect your utility bills—for some older models may eventually need gasket replacement. Pumps and internal water heaters may also eventually fail and need repair or replacement.

**When is it time to replace?**

The expected lifetime of a dishwasher is about 10-12 years, and as it ages, the likelihood of repairs and replacement increases. As with refrigerators and freezers, the opportunities for replacement include:

- **Costly repairs.** If an estimate for repairs exceeds several hundred dollars, it might make sense to look at replacement instead—depending on the age and condition of the rest of the appliance.
- **Remodeling project.** A kitchen remodel often includes an upgrade of appliances, in order to accommodate a different space or additional features.

**Dishwashers**

At one time dishwashers were relatively rare in households; today they are a common component of many kitchens. Aside from obvious convenience and time-saving, dishwashers can also help to sanitize dishes, potentially reducing the occurrence of illness. In addition, an efficient dishwasher will usually use less hot water than washing dishes by hand.

**Maintenance and repairs**

Depending on the model and features, dishwashers require very little maintenance to keep them running well. Screens on the bottom that trap large particles may need to be emptied and the spray arms need to spin freely. Door gaskets should fit tightly to avoid leakage; some older models may eventually need gasket replacement. Pumps and internal water heaters may also eventually fail and need repair or replacement.
IMPF, FW, & HE Washers

Clothes washers must meet minimum efficiency standards in order to be ENERGY STAR® labeled, including:

- Integrated Modified Energy Factor (IMEF) is a measurement of the energy efficiency of the washer, taking into account the electric energy, the energy to heat the water, and the size of the tub. ENERGY STAR® front loading washers must have an IWF of 2.76 or greater. Top loading washers must have an IWF of 2.06 or greater.
- Integrated Water Factor (IWF) is the measurement of how much water is used, related to the capacity of the machine. ENERGY STAR® front loading washers must have an IWF of 3.2 or less. Top loading units must have an IWF of 4.3 or less.

The latest design in energy-saving laundry appliances is known as the High Efficiency (HE) washer. Nearly all HE washers are front-loaders (although some top loaders are now available) and they have several advantages over less-efficient versions.

HE washers:
- Use less water. Because they tumble clothes rather than agitate them, HE washers can use up to 75% less water than a standard washer.
- Use less hot water. Using less water means using less hot water, which saves the energy to heat the water (nearly 90% of the energy used in a typical washer).
- Wash less. A spin cycle of 1,000 rpm removes much more water, and a moisture sensor limits the spin time. Less water at the end of the wash means less energy needed to dry the clothes.
- Are gentler on clothes. The tumble action is easier on clothes than a typical agitator.
- Require a special HE detergent. Because of how an HE washer operates, regular detergent will over-suds and not work properly. Buy only HE detergent and follow instructions carefully. (You use much less than with regular detergent.)

High energy usage. A dishwasher that was made before 1996 will probably use up to 10 gallons of water per cycle and cost you $40 more in energy costs annually than a newer ENERGY STAR® model.

Shopping tips

- When evaluating a new dishwasher, look closely at these features:
  - Water heating. A dishwasher with a built-in heater and adjustable temperature settings gives you a variety of options: a lower temperature for china, a moderate one for day-to-day use, and a higher temperature for heavy cleaning. And heating the water in the appliance allows a lower setting of 120 degrees on your main water heater, saving energy and avoiding scalds.
  - Sensors. Knowing how soiled the water is (and thus how dirty the dishes are) permits the dishwasher to adjust wash times and water temperature automatically, saving time and energy.
  - Food grinder. This option eliminates the need for emptying screens before each use and helps sensors know when cleaning is complete.
  - Delayed start time. Setting the dishwasher to operate late at night can reduce electric grid system loads and can keep you from running out of hot water for showers or laundry.

Efficient use

Follow these suggestions to keep your energy usage to the minimum:

- Wash only full loads. Even with a sensor, you will still use nearly the same amount of hot water and electricity, regardless of how many dishes are inside.
- Do not pre-rinse dishes. It wastes hot water and is unnecessary with newer dishwashers. A simple scrape to remove the biggest pieces is usually sufficient.
- Use the least amount of detergent that will still clean your dishes. Excess detergent use can lead to spotting and staining, as well as environmental concerns.

Laundry equipment

The typical household in America cleans and dries about 300 loads of laundry a year. Up to 90% of the energy used to wash clothes is used to heat water, and the energy use of dryers is directly related to the moisture content of the clothes; these two factors illustrate the energy-saving opportunities in a typical laundry room.

Maintenance and repairs

Older washers and dryers may require periodic maintenance to keep them operating properly. Here are a few things to check for:

Washer:
- Clean the tub of your washer every few months (or more often if indicated by odor or stains). Special cleaning products can be used in place of detergent and run through a complete cycle. Check with the manufacturer for recommendations.
- Inspect water and drain connections periodically for leaks. A buildup of rust or minerals at connections or stains along the side of the washer or on the floor indicate a need to replace:
  - Replace water supply hoses that connect to washers every 3-4 years. The hoses can become brittle and susceptible to failure, leading to a flooded basement or laundry room.
  - Pumps and motors have a limited lifetime; repairs or replacements may eventually be needed.

Dryer:
- Clean the dryer lint screen before each load.Lint restricts airflow and increases drying time and energy use.
- Only vent dryers to the outside! Venting into the living space or attic will lead to high levels of moisture. In a basement it can lead to significant mold and mildew issues; in an attic it will lead to wet insulation, rot, and ice dams. Venting a dryer into the living space is usually a special High Efficiency (HE) type.
- Front-loaders spin at a much higher rate of speed (1,000 rpm or higher), wringing much more water out of the clothes. This significantly reduces the energy required to dry the clothes.
- Front-loaders are frequently gentler on laundry, due to the tumbling action of the clothes, rather than the movement of the agitator in a top-loader.
- Top-loaders are generally cheaper to purchase, initially; when factoring in energy savings, however, the purchase price will be offset over the life of the appliance.
- Top-loaders are generally easier to load and unload for many people. Front-loaders, however, can be mounted on stands or have the dryer stacked on top to save floor space.
Follow these suggestions to keep your laundry energy usage to the minimum:

- **Efficiency.** Choose an ENERGY STAR® model with an IMEF of 2.76 or greater for front loading units and 2.06 or greater for top loading units and a IWF of 3.2 or less for front loading units or 4.3 or less for top loading units. Both IMEF and IWF numbers are listed for each model on the ENERGY STAR® website.

When evaluating a new dryer, look closely at these features:

- **Sizing.** Match the size of your dryer to the size of your washer.

- **Electric versus gas.** Although gas dryers may cost slightly more (for similar size and features), your choice may depend on the availability of certain fuels (and their connections) in your home. Other factors, such as health and safety concerns or the environmental effects of different fuels, may also inform your decision.

- **Features.** Dryers with sensors evaluate the moisture content of the laundry and reduce drying times. This is far better than using a timed cycle, which may over-dry clothing, wasting energy and potentially damaging clothes. Options for temperature settings allow for optimal use with different fabrics. Additional features, such as wrinkle-reducing cycles and drying racks, may not add significantly to energy use, but may be important convenience considerations.

- **Efficiency.** An efficient washer (with a high spin rate) will wring most of the water out before you put the clothes in the dryer—reducing drying time and energy use. New washers will remove 95% or more of the water content of the laundry and reduce allergy issues from dust mites. Lower dryer temperature settings to allow for longer drying times. This method can also reduce wrinkles and eliminate ironing for many clothes. (See sidebar on page 55 for caution about indoor drying.)

- **Air-dry clothes outside to reduce dryer usage.**

### Cooktops, ranges, and microwaves

The energy-related differences among the various ways to cook and bake food in most homes is relatively small—often less than 10% per year on average. There are presently no ENERGY STAR® standards for these appliances.

#### Shopping tips

The expected life of most ranges and cooktops is 14-20 years; microwaves should last about 10 years. These appliances are usually fairly reliable over their expected life; an estimate for repairs of several hundred dollars might suggest replacement. Many newer models have additional features and approaches to heating food. When buying range or cooktop replacements, ask about:

- **Fuel choice.** Because the difference in energy use is relatively small, this is usually based on the available fuels and connections in your kitchen. Cooking preferences, indoor air quality, safety, and adding to electric loads may also be factors for some people.

- **Burner styles.** Whether coils, smooth-top, enclosed, induction, or halogen, burner styles are largely a matter of personal choice and budget. Some options may heat more quickly; others may leave less residual heat on the cooktop, and thus be safer.

- **Controls.** Controls located on the front are much safer than those that require you to reach over burners and hot pans. Newer models have lock-out features to prevent accidental use by children or pets.

- **Other options.** Features such as dual timers, convection heating, lighting, warming drawers, intelligent cooktops, etc. may all be important to your cooking styles; again, the energy consequences for most home use are relatively small.

#### Microwaves

Microwaves are slightly more energy efficient for some cooking tasks, but their main advantage is faster cooking time. The higher the wattage, the less time it takes items to be heated. When selecting a microwave consider the intended uses in order to properly size the unit.

### Efficient use

There are a few things you can do to make cooktops, ranges, and microwaves work as efficiently and safely as possible:

- **Plan your meals to use the heat from your oven to cook multiple items. Baking a squash? Throw in a couple of potatoes for tomorrow’s meal.**

- **Open oven doors only when necessary; the temperature can drop 30 degrees in just a few seconds.**

- **Don’t place foil on the bottom of a gas oven; it may interfere with the flow of air to the burners.**

- **Use pots and pans that are sized to fit the burner size on your cooktop. Pans that are too small for the burner allow heat to escape along the sides. Ones that are too large may not distribute the heat evenly across the bottom of the pan.**

- **When heating food in a microwave, do it in stages, with frequent stirring or turning. Microwaves may not penetrate into the interior of some foods, and thus not kill food-borne bacteria.**

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Lighting a typical Minnesota household accounts for about 10% of the energy needed to operate the home. There are many opportunities to affect that energy use, such as selecting efficient products and using them appropriately.

Saving energy with good lighting design

In the past, flipping a switch would flood a room with light, regardless of what you were going to do in the space. Today, good lighting design includes options for fixtures, controls, and bulbs—based on how the space will be used. The addition of light emitting diode (LED) bulbs and fixtures has opened a heretofore unknown range of lighting designs and opportunities to have the right amount, color, and type of lighting where and when it is needed.

Lighting falls under one of four general categories, based on the use of the space to be illuminated. Well-designed lighting incorporates components of all four types in many rooms within a home.

General

Used to provide a basic level of ambient illumination in a room, general lighting can range from a single ceiling fixture to dimmer-controlled wall sconces. Often overlooked, general lighting can establish a mood or complement other lighting options for a room.

Task

Designed to give focused and brighter lighting to workspaces, task lighting is used for food preparation, reading, or working on projects. Down lights, under-cabinet lights, track lights, or lamps are common sources of task lighting.

Accent

Used to provide illumination for works of art or architectural features, accent lighting can include track lights, indirect lighting, or wall-wash lighting.

Decorative

With the focus primarily on the fixture itself, decorative lighting includes chandeliers and lamps. Because the light provided is usually incidental, decorative lighting frequently is combined with other lighting styles to provide appropriate illumination.

Fixtures

The devices that contain light sources are known as fixtures. Although it may not seem obvious at first glance, fixture choices can have a significant effect on the usefulness of lighting—which can also affect energy use.

Surface mount fixtures

Typically found on ceilings or walls, surface-mounted fixtures are hard-wired directly to an electrical box and usually controlled by a wall switch. A common type of lighting in most homes, surface-mounted fixtures are found in nearly every room of a house and include bedroom ceiling lights, dining room chandeliers, bathroom wall sconces, outdoor security lights, and single-bulb basement fixtures. Track lighting, which can be either standard voltage or low voltage, usually uses surface-mounted fixtures. Often used as accent lighting or to illuminate art, track lighting can also be used to provide focused task lighting in kitchens or work areas.

Recessed fixtures

Light fixtures that are recessed into the space above the finished ceiling are commonly known as down lights or can lights. Designed to provide focused light at a particular location, these fixtures are controlled by a wall switch and direct light straight down or, with the use of partial shields or reflectors, direct light towards one direction. Recessed light fixtures that enter the attic space are required to be saving energy with bulbs

In the past, flicking a switch would flood a room with light, regardless of what you were going to do in the space. Today, good lighting design includes options for fixtures, controls, and bulbs—based on how the space will be used.

Today there are many choices for bulbs—way beyond just the standard incandescent bulb. These choices allow consumers to better meet their lighting needs—while considering performance, bulb life, initial cost, operating cost, and energy efficiency.

Plug-in fixtures

Light fixtures that are not directly wired to the home electrical system require a cord to plug into an outlet. These include floor, table, and desk lamps as well as specialty lighting like some under-cabinet fixtures or picture lights. The flexibility of many plug-in lamp fixtures makes them a good choice for a variety of lighting needs. However, the use of cords (and extension cords) for plug-in lamp fixtures can present hazards. Cords should run along walls wherever possible and should not extend into traffic areas. Extension cords should be rated by Underwriters Laboratories for the intended use. If cords or plugs are cracked or loose, they should not be used until repaired/replaced.

Bulbs and other options

The standard incandescent light bulb (which had changed very little since Edison’s time) was the only real choice for most home lighting until fairly recently. The move to energy efficient lighting brought compact fluorescent bulbs (CFLs), which greatly reduced electrical demand for lighting. Today, light emitting diodes (LEDs) combine high efficiency, superior controllability, extensive color and brightness options, and lower environmental concerns for everyday lighting needs. Even though LEDs are currently dominating the home lighting market, many people still have other technologies and fixtures in place in their homes.

Incandescent bulbs

As electrical current passes through the filament in an incandescent bulb, it is heated to a high temperature (400°-500°) which causes it to glow with visible light. Because nearly 90% of the energy input is emitted as non-visible infrared (heat), incandescent bulbs are much less efficient than other types that provide the same amount of light. Incandescent bulbs also have a relatively short expected lifetime—between 750-1,000 hours for a general service bulb. Additionally, because of their energy inefficiency, most incandescent bulbs have been phased out of the marketplace. In some circumstances (oven lights, for example), incandescents are the only available option.

Halogen bulbs

While essentially an incandescent bulb, halogen bulbs are infused with inert halogen gas and have a quartz shell. Although commonly used in desk lamps, work lights, and track lighting, halogen bulbs are also available as spot or flood lights for use in recessed fixtures or outdoor lighting. Halogen torchieres (tall floor lamps that direct light towards the ceiling) are also popular; they can present a fire hazard if not properly used, however.

Tube fluorescent bulbs

Available since the 1940s, tube fluorescent bulbs have been commonly seen in public buildings, schools, commercial buildings, retail stores—nearly everywhere that lighting is used. Even in residential homes, tube fluorescents have been found in basements, garages, and workshops. As LEDs have entered the lighting market, however, the lower efficiency, control options, and short life expectancy along with the higher environmental and disposal concerns have pushed most new tube fluorescents out. There are LED replacements bulbs for existing tube fluorescent fixtures, for example.

Compact fluorescent bulbs

Once the primary pathway to lighting efficiency in homes, CFLs have been largely supplanted by LEDs for most uses. The perceived shortcomings of CFLs—slow start-up; poor performance in low temperature environments; flickering; limited dimmability, color, and brightness options; and environmental concerns regarding disposal—essentially crippled the CFL bulb as LED’s gained market share. It is important to point out, however, that CFLs have better efficiency than incandescents, so there is nothing wrong with continuing to use them for some lighting needs. At the end of their life, however, they must be properly disposed.
LEDs: Today’s lighting option

Nothing since the invention of the incandescent bulb has changed the way we light our homes, public buildings, business- ness, streets, and even televisions, as much as LED technology. Also known as Solid State Lighting (SSL), light emitting diodes (LEDs) have been used in electronic devices (like laboratory equipment and calculators) since the 1960s. Advances in recent years initially moved LEDs into lighting for retail and commercial business— including streetlights, architectural lighting, and freezer display cases. As costs declined, LEDs have now been fully integrated into the marketplace, offering new opportunities for homeowners.

LED bulbs have several characteristics that make them suitable for nearly all applications in homes and businesses: high efficiency, long life, bulb-less options, wide range of brightness and color choices, styles for every lamp and fixture, controllability with dimmers, sensors, and smart-home integration, and fewer disposal restrictions. And as costs have continued to fall, LED bulbs are now the best deal over their lifetime.

Efficiency
LED bulbs are up to 10 times as efficient (measured as lumens/watt) as comparable CFLs. According to the Department of Energy, widespread use of LEDs by 2025 could save about 348 TWh (compared to no LED use) of electricity: This is the equivalent annual electrical output of 44 large electric power plants (1000 megawatts each), and a total savings of more than $30 billion at today’s electricity prices. The associated levels of carbon emissions from electricity generation would also be significantly reduced.

Long life
LED bulbs have long estimated lifetimes—15-25 years at three hours/day, which is up to 20 times longer than an incandescent and at least three times longer than a CFL. The longer life makes them a good choice for locations where bulb change-outs are either difficult or costly, and it easily offsets their slightly higher than incandescent purchase cost.

Bulb-less fixtures
With the advent of LED technology, a new category of lighting fixture is now possible: bulb-less or integrated fixtures. Rather than a fixture that accepts a bulb (including the screw-in base and the space for the encapsulated bulb), the individual LEDs are mounted directly into the fixture. For many uses, the cost of an integrated fixture is less than the cost of a standard fixture and an LED bulb.

Because integrated fixtures have all of the advantages of LED technology (directionality, dimmability, color tuning, long life, low heat output, low energy use), they can accommodate a wider range of creative designs, including very thin fixtures (for recessed locations) or very artistic fixtures (such as candelabras or wall sconces). Additional forms include holiday, rope/strip, outdoor landscape, and work/task lighting. We can now have light fixtures be anything from a bare-ly noticeable source of illumination to a piece of art that provides decoration along with brilliance.

The one downside of integrated fixtures is that there are no (presently) consumer-replaceable parts; when the LEDs are at the end of their life, the fixture is as well. But depending on the quality of the product and the usage, that lifetime could easily extend to 20+ years.

Brightness and color options
Bulb-style LEDs are available from under 100 lumens to over 6,500 lumens (the measure of brightness). Many of today’s LED bulbs can be controlled using dimmer switches, occupancy sensors, or timer switches to reduce energy use as well as provide convenience and security. With instant-on and no cold-weather limitations, LED bulbs can be used in locations where other bulbs have poor performance. The ability to control lighting with smart-home systems provides opportunities to set lighting schedules based on occupancy, time of day, activities, and more—whether from within the home or remotely.

Choosing the right lighting

Light bulb options used to be simple—and limited. Residential choices were between incandescents and tube fluorescents; shops, basements, and laundry rooms got the fluorescents and everywhere else the incandescents. The only thing to decide was how many watts you needed.

What about watts?
Watts are a measurement of energy usage that became a convenient shorthand for describing the brightness of an incandescent bulb. Today, with so many types of lighting to choose from, knowing the wattage tells us little about other important characteristics: brightness, color temperature, lifetime, or environmental impact. As consumers, we need to change our lighting schedules based on occupancy, time of day, activities, and more—whether from within the home or remotely.

What about mercury in CFLs?
All fluorescent bulbs (both tube and CFL) contain small amounts of mercury vapor—between 1 and 5 milligrams in a CFL bulb. For comparison, a mercury thermometer contains 500 milligrams—about the same amount in a dental amalgam. In an unbroken CFL bulb, the mercury is contained: accidental breakage can release the mercury. Although the risks associated with the breakage of a single CFL bulb have been sometimes exaggerated, proper cleanup and disposal is recommended (epa.gov/cfl). Recycling of burned out CFL bulbs is required by law, so that the mercury and other components can be captured and re-used. Check with your county hazardous waste disposal program, electric utility, or retail store for locations for CFL recycling.

Bulb comparisons

The table below illustrates differences in cost and efficiency for selected light bulbs; different products may have different characteristics. Electricity costs are based on current statewide average, not projected costs. Bulbs selected for comparison are currently available retail products. Watts, efficiency, estimated bulb life, and retail prices are from retailers/ manufacturers. Numbers have been rounded for clarity. Actual performance will vary.

<table>
<thead>
<tr>
<th></th>
<th>Incandescent</th>
<th>CFL</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watts (W)</td>
<td>60</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Lumens</td>
<td>800</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Lumens per watt</td>
<td>13</td>
<td>57</td>
<td>89</td>
</tr>
<tr>
<td>Est. life in hours</td>
<td>1,500</td>
<td>10,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Est. life in years</td>
<td>1.4</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td># of bulbs for 23 yr</td>
<td>17</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Purchase price</td>
<td>$0.84</td>
<td>$2.22</td>
<td>$1.52</td>
</tr>
<tr>
<td>23 yr operating cost</td>
<td>$226</td>
<td>$55</td>
<td>$33</td>
</tr>
</tbody>
</table>

1. Based on operating 3 hrs/day
2. Number of bulbs required over 23 years, operating at 3 hours per day, based on estimated life of bulbs.
3. Cost to operate 3 hrs/day at 14¢/KWh for 23 years (the estimated life of the longest-lasting bulb) plus the cost of needed replacement bulbs.
how we evaluate lighting to ensure we match our light needs with the proper bulbs and fixtures.

**Lighting Facts Per Bulb**

- **Brightness**: 800 lumens
- **Estimated Yearly Energy Cost**: $0.89
  - Based on 3 hrs/day
  - Cost depends on rates and use
- **Life**: 22.8 years
  - Based on 3 hrs/day
- **Light Appearance**
  - Warm: 2700 K
  - Cool: 4500 K
- **Energy Used**: 9 watts

**Color Temperature**

<table>
<thead>
<tr>
<th>Color Temperature</th>
<th>Brightness</th>
<th>Life</th>
<th>Energy Used</th>
</tr>
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<tbody>
<tr>
<td>Warm 2700 K</td>
<td>800 lumens</td>
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</tr>
<tr>
<td>Cool 4500 K</td>
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<td>9 watts</td>
</tr>
</tbody>
</table>

**Lumen**: The measure of the brightness of light as perceived by the human eye. It is measured independently of the type or wattage of the lighting and provides a more accurate view of how we actually see the illumination. A typical 60-watt incandescent bulb provides about the same lumen as a 14-watt CFL or a 9-watt LED, for example. Higher the rated lumen output of a bulb the “brighter” the light is. Lower lumen output (under 600) may be best suited for decorative or mood lighting. Higher lumen bulbs (over 3,000) may work best for task lighting, especially if the bulbs are directional, such as a spotlight. Choose the brightness best suited for your use.

**Color temperature makes a big difference**

All lighting emits different frequencies (or colors) of light, depending on the type, materials used in the manufacturing, and electronic components. The human eye perceives redder colors as “warmer” and thus more natural for general illumination; bluer or “cooler” colors are perceived as providing sharper detail, well-suited for task lighting.

Somewhat confusingly, the lower the color temperature (measured in degrees kelvin or “K”) the warmer the light. Incandescent bulbs are typically in the range of 2,700K to 3,000K; fluorescent bulbs can range from 2,000K to “bright-white” bulbs of 5,000K. LEDs are now available with color temperatures ranging from warm 2,200K to cool 6,000K. Choose the color temperature best suited for your use.

**Size and shape of bulbs**

Certain lamps and fixtures have specific requirements for what type of bulb can be used to fit. Although the options for LEDs were initially limited, today one can find options for nearly any type of fixture or lamp. Choose the bulbs that work best with your lamps or fixtures.

**Efficiency: Lumens per watt**

Although any low wattage bulb will deliver energy savings, the only really accurate comparison is how much light (lumens) you get for a specific amount of energy (watts). Presently, LED bulbs offer the highest efficiency options, with most delivering 70-90 lumens per watt—compared with under 14 lumens per watt for incandescent bulbs. The energy savings in a typical household could work out to $100-$200 per year by switching from incandescent to LEDs. Choose efficient ENERGY STAR® bulbs when replacing your lighting.

**Labels make it easier to choose**

Thanks to labeling requirements from the Department of Energy and the Federal Trade Commission, choosing light bulbs based on lumens, color temperature, and efficiency is now considerably easier. These labels also include information on estimated annual energy costs, estimated lifetime, disposal requirements, and whether the bulb meets ENERGY STAR® standards. When shopping for light bulbs, consumers can more easily compare characteristics between several bulbs, and make choices to best fit their needs.

**Look for the label to make the right lighting choices.**

**Lighting controls**

Managing when lights are on and at what level of output is an important way to reduce energy use for lighting. Manually operating switches is the easiest way to control lighting in many situations. Simply turning off a light when leaving a room is efficient and simple. It does, however, rely on one individual—often the least reliable factor: human behavior. In some situations, controlling lighting automatically will not only save energy and money, it can also provide safety and convenience. Lighting control options include dimmers, timers, motion detectors, and smart-home systems.

**Dimmer switches**

A typical dimmer control switch reduces the electrical current to a light fixture, reducing light output and saving energy. Traditionally used with incandescent bulbs, dimmers will also work with most LED bulbs (be sure your dimmer switch is rated for LEDs). Bulbs that are not designed to be used with a dimmer may burn out prematurely or overheat. Check the packaging or manufacturer to avoid performance or safety problems.

**Timers**

Many devices, including lighting, can be controlled with a timer. Having selected lights come on when occupants arrive home and off at bedtime, for instance, can provide convenience and safety. Security concerns can be addressed by having lights come on when on vacation as well. The timer avoids the energy wasted from having lights on and over long periods of time.

**Motion detector fixtures**

In locations where light is needed but the switch is not conveniently located, a motion detector fixture can provide a good alternative. Choosing the right level of output can require a light sensor to avoid activation during daylight hours. Lights outside front and back doors, entrances or driveways near garages can be set to come on at night when movement is detected and turn off in a set amount of time. Outdoor motion detector fixtures also provide security and safety, warning of intruders and lighting walkways and steps. The sensitivity and range of these light fixtures should be adjusted so that they are not triggered by small animals or wind-blown trees. LEDs are a good choice for these fixtures because of brightness and long life.

**Occupancy sensor switch**

Commonly seen in public restrooms and commercial buildings, occupancy switches are available for home use. They are particularly useful in areas that are occupied frequently (bathroom or laundry) or in locations where the switch is inconveniently located (at the far end of a hallway or stairway). They can also control lighting that a wall switch operates—such as a bathroom fan. Once activated, the switch can be set to turn off following a set amount of time after no movement is detected.

**Smart-home lighting controls**

The opportunities to design lighting for specific spaces or uses—and to make changes through smart lighting controls—has opened a new world of possibilities for safety, security, convenience, ambiance, and energy use. Controlled through smart phones or voice activation with Wi-Fi systems, smart LED lighting can be connected directly to the internet. Lights come on when occupants arrive home and off at bedtime, for instance, can provide convenience and safety. Security concerns can be addressed by having lights come on when on vacation as well. The timer avoids the energy wasted from having lights on and over long periods of time. Outdoor motion detector fixtures also provide security and safety, warning of intruders and lighting walkways and steps. The sensitivity and range of these light fixtures should be adjusted so that they are not triggered by small animals or wind-blown trees. LEDs are a good choice for these fixtures because of brightness and long life.

**Occupancy sensor switch**

More commonly seen in public restrooms and commercial buildings, occupancy switches are also available for home use. They are particularly useful in locations where the switch is inconveniently located—at the far end of a hallway or stairway or where lights are left on for safety or security, such as in a garage or basement.
Although electronic devices like TVs, DVD players, and computers consume a relatively small percentage of the energy to operate a typical Minnesota household, it may be possible to cut electricity use for home electronics in half—without much effort.

**Buy ENERGY STAR®**

The best way to save energy with electronics is to always replace and upgrade with ENERGY STAR® products. ENERGY STAR® televisions, for example, are 25% more efficient than conventional models and audio/video equipment is up to 60% more efficient. Until you replace, there are some things you can do to reduce energy use in existing equipment, however:

**Home entertainment equipment**

Televisions, CD and DVD players, cable boxes, stereo receivers, and video gaming systems can use a lot of electricity, even when they appear to be off. Some older TVs, for example, can use up to 40% of the full “on” power when in stand-by mode. The cheapest way to reduce electricity that is being used by these devices is to unplug them when you don’t need them. No additional purchases or special tools are required—just a willingness to be vigilant. Controlling them with a convenient outlet strip can make it easier; a “smart” outlet strip will turn off peripherals (DVD players, game systems) when a primary device (TV) is turned off. Because some devices may require re-programming, you may need to be selective about what you turn off.

**Computers and peripherals**

A recent study conducted by the Energy Center of Wisconsin indicated that up to 80% of the computers in the study did not have sleep/hibernate enabled. Many people mistakenly believed their computers were in sleep mode because their monitors were asleep; in fact, the settings had not been enabled on the computer. Enabling these features can save up to 300 kWh of electricity every year.

A simple trip to your control panel settings for power management will allow you to configure your system to reduce electricity use. Computers that are asleep will still receive updates and be available for other activities (like video streaming to your TV). Peripherals (printers, modems, scanners, etc.) can be controlled by turning off, unplugging, or using a smart outlet strip.

**Chargers**

Most of us have numerous devices that have rechargeable batteries: mobile phones, flashlights, power tools, etc. Even though the amount of power used by each of these may seem insignificant, they may continue to draw small amounts of electricity, even when fully charged and the device is disconnected.

Fortunately, there is an easy way to curb this wasted electricity: charging stations. An inexpensive timer can be set to operate for an hour or two at night. Plug an outlet strip into the timer and the devices to be charged into the outlet strip. If located conveniently (kitchen or bedroom for mobile phones, basement for tools), it becomes easy to keep devices fully charged with minimal wasted electricity.

**Energy savings**

The following resources should get you on the way to making energy-saving improvements in your home. Remember, whether doing the work yourself or hiring a contractor, it is important that you have a good understanding of the options and opportunities available. This checklist will help you make the best choices for your home and budget:

**Pre-work inspection**

An independent energy assessment or home performance review is an essential first step to evaluating how your house is currently operating. Proper diagnosis (from someone who is not selling specific products or services) can lead to energy-saving suggestions based on actual measurements and analysis—not on speculation or exaggerated claims.

- At minimum, assessments should evaluate mechanical systems, combustion appliances, insulation, and air leakage.
- Recommended tests include a blower door reading, a combustion appliance analysis, and an infrared scan.
- Local utility or community energy organizations can provide an energy assessment or home performance review. Contact your local gas or electric utility to learn where to get an energy assessment.

**Education and research**

Once you have a report in hand with specific recommendations, it is time to learn a little more about your options. Information is available from many sources—the task is finding what is trustworthy and useful.

- **Government and nonprofit organizations** provide background on building science, design, and energy conservation and efficiency options. Some provide efficiency data on products, enabling easy comparisons by consumers. Others provide information about specific programs or services, including loans, incentives, and rebate opportunities. Check out: [energystar.gov](http://energystar.gov), [eere.energy.gov](http://eere.energy.gov), or [dsireusa.org](http://dsireusa.org).
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Selecting a contractor

• Go to our website
• Check out licensure on contractors you are considering. A disreputable or unqualified contractor’s misconduct. The Department of Labor and Industry establishes standards and safeguards to help homeowners avoid hiring unlicensed contractors. Be wary, however, of exaggerated claims or unrealistic expectations. The best information provides a balanced perspective on options including professional, academic, or industry evaluations and consumer or media reviews.

• Go to our website (mn.gov/commerce) and sign up for our e-newsletters on topics ranging from energy efficiency tips to notifications of grants and funding opportunities. We also post information about consumer alerts on specific products or companies.

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